Eastern Scotian Shelf Integrated Management (ESSIM) Initiative

Developing Objectives and Indicators for Marine Ecosystem-Based Management: International Review of Marine Ecosystem-Based Management Initiatives throughout the World

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Oceans and Coastal Management Report 2005-09

Fisheries and Oceans Canada | Pêches et Océans Canada | Canada

106-01383/

Oceans and Coastal Management Report 2005-09

DEVELOPING OBJECTIVES AND INDICATORS FOR MARINE ECOSYSTEM-BASED MANAGEMENT: INTERNATIONAL REVIEW OF MARINE ECOSYSTEM-BASED MANAGEMENT INITIATIVES THROUGHOUT THE WORLD

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November 2005

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LIST OF ACRONYMS

ESD	Ecologically Sustainable Development
CPUE	Catch per unit effort
CSIRO	Commonwealth Scientific and Industrial Research Organization, Australia
DEP	Department of Environmental Protection, Australia
DFO	Department of Fisheries and Oceans, Canada
EcoQ	Ecological quality
EcoQO	Ecological quality objective
EEA	European Environment Agency
ESSIM	Eastern Scotian Shelf Integrated Management
FAO	Food and Agriculture Organization
FRDC	Fisheries Research Development Corporation
GEF	Global Environment Facility
HELCOM	Helsinki Commission
ICES	International Council for the Exploration of the Sea
ICOM	Integrated Coastal and Ocean Management
ICZM	Integrated coastal zone management
IOC	Intergovernmental Oceanographic Commission
IMM	Intermediate Ministerial Meeting
IUCN	International Union for the Conversation of Nature
KPI	Key Performance Indicator
LME	Large marine ecosystem
MEQ	Marine environmental quality
MPA	Marine protected area
MSE	Management strategy evaluation
NOAA	National Oceanic and Atmospheric Administration, US
NSESD	National Strategy on Ecologically Sustainable Development
NWS	North-West Shelf, Australia
OSPAR	Oslo-Paris Commission
PCB	Polychlorinated biphenyls
PNCIMA	Pacific North Coast Integrated Management Area
SCFA	Standing Committee on Fisheries & Aquaculture
SERMP	South-East Regional Management Plan
UK	United Kingdom
UNEP	United Nations Environment Programme
US	United States
WCPA	World Commission on Protected Areas
WWF	World Wildlife Fund for Nature

PREFACE

As part of the Eastern Scotian Shelf Integrated Management (ESSIM) Initiative, Fisheries and Oceans Canada has undertaken a program to develop a set of objectives and related indicators for the objectives-based management of the Eastern Scotian Shelf off Nova Scotia, Canada. Objectives-based management applies an outcomes-oriented management system that ensures planning, development and management of marine areas and resources in a manner that addresses the multiple needs and expectations of society. As part of the development process of the ESSIM ecosystem and human use objectives framework, an international review was initially undertaken in January 2004 to identify marine ecosystem-based initiatives globally and to analyze them for guidance on the development of ESSIM objectives (Walmsley, 2004).

This report now updates the 2004 report to include the most recent information on these initiatives by identifying ecosystem-based marine management initiatives throughout the world that have developed or were developing a system of objectives and indicators for management and reporting; evaluating the approaches taken to develop objectives and indicators; and analytically comparing the outcomes of each initiative to each other and to those of the ESSIM Initiative. Of the 23 ecosystem-based marine management initiatives identified in this review, only nine have developed objectives and/or indicators and none have yet achieved full implementation. The report provides valuable lessons learned and highlights the approaches to develop objectives and indicators, the predominant focus on ecosystem objectives *vs.* human use objectives, and the variation in terminology used in each initiative.

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PRÉFACE

Dans le cadre de l'initiative de Gestion intégrée de l'est du plateau néo-écossais (GIEPNE), Pêches et Océans Canada a entrepris d'élaborer un ensemble d'objectifs et d'indicateurs connexes applicables à la gestion par objectifs de l'est du plateau néo-écossais, situé au large de la province canadienne de la Nouvelle-Écosse. La gestion par objectifs est une forme de gestion axée sur les résultats, qui permet de faire en sorte que la planification, la mise en valeur et la gestion du milieu marin et de ses ressources tiennent compte des besoins et des attentes multiples de la société. Dans le cadre du processus d'élaboration de cet ensemble d'objectifs visant l'écosystème et les utilisations anthropiques dans l'est du plateau néo-écossais, une étude internationale a été entreprise en janvier 2004. Elle visait à recenser les initiatives de gestion écosystémique du milieu marin prises dans le monde entier et à les analyser pour qu'elles puissent guider l'établissement des objectifs de la GIEPNE (Walmsley, 2004).

Le présent rapport actualise celui de 2004 en présentant les renseignements les plus récents à ce sujet. Il recense les initiatives de gestion écosystémique du milieu marin qui ont été prises dans le monde entier et dans le cadre desquelles on avait établi ou on allait établir un système d'objectifs et d'indicateurs pour orienter la gestion et pour en rendre compte. Il évalue aussi la démarche suivie dans l'élaboration de ces objectifs et indicateurs, et il présente une analyse comparative des résultats de chaque initiative, les uns par rapport aux autres et également par rapport aux résultats de l'initiative de GIEPNE. Des objectifs ou des indicateurs étaient associés à neuf seulement des 23 initiatives de gestion écosystémique du milieu marin recensées et aucune de ces initiatives n'était encore pleinement mise en œuvre. Le rapport tire des leçons utiles de ces expériences et rend compte des démarches adoptées dans l'élaboration d'objectifs et d'indicateurs. Il fait état également de l'accent qui est mis plutôt sur les objectifs écosystémiques que sur ceux qui visent les utilisations anthropiques et de la variation dans la terminologie utilisée pour chaque initiative.

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1.0 INTRODUCTION

Under the 1997 *Oceans Act*, Fisheries and Oceans Canada (DFO) is required to lead and facilitate the development of integrated management plans for Canada's oceans. One of the integrated management projects is the Eastern Scotian Shelf Integrated Management (ESSIM) Initiative, which commenced in December 1998. Through the ESSIM Initiative, the Oceans and Coastal Management Division (OCMD), Fisheries and Oceans Canada (DFO) Maritimes Region, has been working with a range of stakeholders to develop the Integrated Ocean Management Plan (ESSIM Plan), which was released in February 2005 (ESSIM Planning Office, 2005).

As part of the ESSIM Initiative, DFO has undertaken a program to develop a set of objectives and related indicators for management of the offshore area. Of particular importance in this context is the adoption of objectives-based management as a marine management approach by the ESSIM Initiative. The objectives-based management approach is essentially an outcomes-oriented management system that ensures planning, development and management of marine areas and resources in a manner that addresses the multiple needs and expectations of society, without jeopardizing the options for future generations to benefit from the full range of goods and services provided by the ocean. Objectives for a future state are set and management strategies to reach those objectives are developed.

In early 2004, during the initial stages of developing the objectives and indicators for ESSIM, the OCMD commissioned an international review of ecosystem-based marine management initiatives from around the world that had adopted objectives-based management (Walmsley 2004). The aims of the review were to:

- Identify ecosystem-based marine management initiatives throughout the world that have developed or are developing a system of objectives and indicators for management and reporting.
- Evaluate the approaches taken to develop objectives and indicators and compare the outcomes of each initiative with those of the ESSIM Initiative.
- Make recommendations for further development of objectives and indicators as part of the ESSIM initiative.

Since then, the ESSIM Initiative has progressed considerably in the development of objectives and indicators, for both the ecosystem and human use of the resources of the Shelf. These were presented to stakeholders as part of the ESSIM Plan in January 2005 (ESSIM Planning Office 2005), and are briefly summarised below. This report provides an update of the 2004 international review, and provides a comparison of objectives from other initiatives from around the world with those of ESSIM. Additional information on ESSIM is available at http://www.mar.dfo-mpo.gc.ca/oceans/e/essim/essim-intro-e.html.

2.0 ESSIM OBJECTIVES FRAMEWORK

The ESSIM Objectives framework is a hierarchical framework, comprised of a set of management objectives and an accompanying reporting system (Figure 1) (see ESSIM Planning Office 2005).

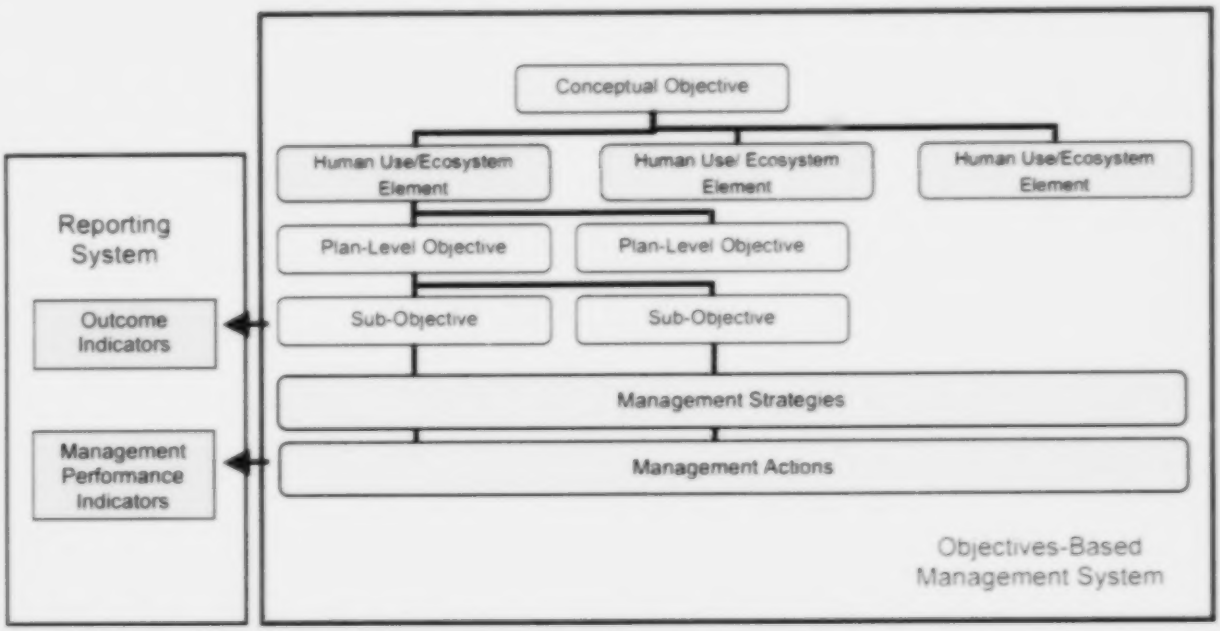


Figure 1 Objectives-based management framework for the ESSIM Initiative

The objectives and elements developed for ESSIM are split into two, ecosystem and human use.

2.1 Ecosystem Objectives

The ecosystem objectives were developed following the 2001 *National Workshop on Objectives and Indicators for Ecosystem-Based Management*, frequently referred to as the Dunsmuir or Sidney Workshop, which was held to discuss a national framework for ecosystem objectives (Jamieson & O'Boyle 2001). The resulting national DFO framework contains two overarching conceptual objectives for ecosystem-based management:

- The sustainability of human usage of environmental resources;
- The conservation of species and habitats, including those other ecosystem components that may not be utilized by humans.

The second of these objectives (*i.e.*, the conservation or ecosystem objective) was sub-divided into three more specific objectives (Figure 2; ESSIM Planning Office 2005):

- To conserve enough components (ecosystems, species, populations, etc.) so as to maintain the natural resilience of the ecosystem;

- To conserve each component of the ecosystem so that it can play its historic role in the foodweb (*i.e.*, not cause any component of the ecosystem to be altered to such an extent that it ceases to play its historical role in a higher order component); and
- To conserve the physical and chemical properties of the ecosystem.

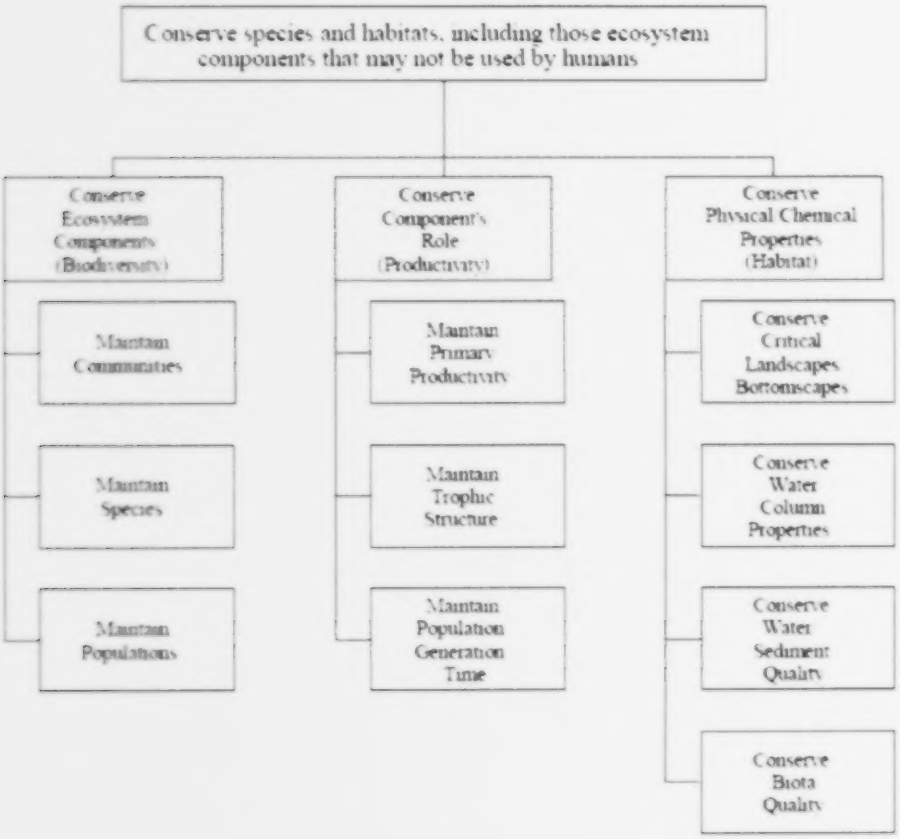

Conserve species and habitats, including those ecosystem components that may not be used by humans
Conserve Ecosystem Components (Biodiversity)
Conserve Component's Role (Productivity)
Conserve Physical Chemical Properties (Habitat)
Maintain Communities
Maintain Species
Maintain Populations
Maintain Primary Productivity
Maintain Trophic Structure
Maintain Population Generation Time
Conserve Critical Landscapes Bottomscapes
Conserve Water Column Properties
Conserve Water Sediment Quality
Conserve Biota Quality

Figure 2 National framework for ecosystem objectives

These three objectives are essentially aimed at preserving ecosystem structure (biodiversity), ecosystem function (productivity) and habitat, respectively. Through the national hierarchical framework (see Figure 2), these objectives are broken down further for the purpose of defining more practical objectives that can be stated in terms of specific indicators and reference points for individual elements of the ecosystem (ESSIM Planning Office 2005). Based on this framework the Maritimes Region ESSIM Science Working Group, established in late 2003, has been developing operational objectives for the ESSIM area as shown in Table 1.

Table 1 Ecosystem elements and plan-level objectives for the ESSIM Initiative

Ecosystem Element	Issue	Plan-Level Objective
Community-related objectives		
Benthic communities	Important communities	Identify and protect important benthic communities (*e.g.* highly diverse or unique communities, productivity hotspots)
	Sensitive communities	Identify and protect coral communities in the Gully and Stone Fence areas
		Identify and protect other sensitive benthic communities
Pelagic communities	Important communities	Identify and protect important pelagic communities (*e.g.* highly diverse or unique communities, productivity hotspots)
	Sensitive communities	Identify and protect sensitive pelagic communities
Communities/ assemblages	Conservation of communities	Maintain/restore identified pelagic fish communities/assemblages (including marine mammals, large pelagics)
		Maintain/restore identified demersal communities/assemblages
		Maintain/restore identified benthic communities/assemblages
		Maintain/restore identified seabird communities/assemblages
Species-related objectives		
Commercially harvested species (objectives for each commercially important species)	Biomass and productivity of finfish	Maintain/restore species, populations and productivity
Species at risk (objectives for each aquatic and seabird species)	Endangered species	Protect and rebuild species

Ecosystem Element	Issue	Plan-Level Objective
Cross-cutting objectives		
All species	Ecosystem structure and function	Maintain/restore bycatch of non-target species within acceptable limits
Invasive species	Ecosystem structure and function	Limit and monitor invasive species
Genetic diversity	Ecosystem resilience	Maintain/restore genetic diversity
Productivity-related objectives		
Phytoplankton/ zooplankton	Ecosystem structure and function	Monitor base of the food chain to detect changes that may affect other ecosystem components (monitoring only)
		Monitor environmental conditions that may influence productivity of base of the food chain (monitoring only)
Trophic structure	Ecosystem function	Preserve natural trophic structure. Preserve adequate forage species for higher level predators
		Preserve traditional role of top predators
Habitat-related objectives		
Rare habitats	Diversity of habitats	Identify and protect rare habitats
Bottom habitat	Physical characteristics of the bottom	Maintain/restore physical characteristics of sediments that are conducive to resident biological populations and diversity of bottom types
	Geochemical processes in sediments	Maintain/restore geochemical conditions (*e.g.* sulfide, redox potential, organic matter content, carbon nitrogen ratios etc.) conditions necessary for functioning of resident community

Ecosystem Element	Issue	Plan-Level Objective
	Toxic chemical contamination of the sediments	Maintain/restore concentrations of toxic chemicals below levels that are harmful to resident biota
Sound environment	Excessive sound levels	Maintain/restore sound levels necessary to protect resident species
Water column	Eutrophication	Maintain/restore O_2 concentrations that are sufficient for productive growth of resident biota
	Chemical contamination	Maintain/restore concentrations of toxic chemicals in water below levels that will cause harm to resident biota
Solid wastes	Non-biodegradable debris	Maintain/restore amounts of solid wastes within acceptable limits
Biota quality	Health of resident biota	Maintain/restore marine environmental quality that is conducive to production of healthy biota
	Contaminant levels in fish	Prevent chemical or biological contamination of species that could be consumed by humans

2.2 Human Use Objectives

In May 2003, a working group was established to assist in the development of the Human Use Objectives Framework as a collaborative process involving a range of stakeholders. Drawing on the expertise of individual sector representatives, the working group proposed a hierarchical framework for objectives and indicators, similar to the framework that was being developed concurrently for ecosystem objectives. The framework was presented to stakeholders at a workshop held in December 2004. The workshop was convened specifically to obtain expert opinion on the framework and objectives from an array of stakeholders, including government managers, industry, academic/technical experts, and community and non-government organisation (NGO) representatives. The framework, objectives and indicators were further developed based on the input from the workshop (Walmsley 2005).

The objectives and indicators that were developed for the Human Use Objectives Framework for ESSIM are summarized in Table 2. Objectives are expressed as goals, while sub-objectives are expressed as outcomes. ESSIM objectives have been developed for each of the four identified human use elements, namely: community well-being; economic well-being; industrial capacity and assets; and integrated management process. There are currently eighteen sub-objectives that reflect requirements of these, with several indicators for each sub-objective, giving a total of 63 recommended indicators.

Table 2 ESSIM human use objectives and sub-objectives

HUMAN USE ELEMENT	ESSIM OBJECTIVE	SUB-OBJECTIVE	INDICATORS
Conceptual Objective: To contribute to social, cultural and economic well-being by achieving ecologically sustainable and integrated use of the ocean space and resources in the ESSIM area			
Community well-being	To contribute to the long-term social and cultural well-being of communities in Nova Scotia	Access by coastal communities and all Nova Scotians to sustainable livelihood opportunities derived from ocean resources	Provincial employment levels per sector (no. of people)
			Legal requirements for access per sector (qualitative explanation)
			Number of licenses issued per sector (no./sector)
			Capital outlay and operating costs per sector per annum ($/annum)
		Nova Scotian community resilience improved	Reported bankruptcies in pilot communities (no.)
			Debt levels per annum in pilot communities ($)
			Marine fisheries landed value by type of fish in pilot communities ($/per type)
			Age structure of community in pilot communities (years)
			Income from economic activities ($/activity)
		Ocean-related education, training and awareness enhanced	Percentage of children at high school level who have understanding of ocean-related issues (%)
			Number of ocean-related curriculum elements at elementary, junior high and high school levels by school board (no.)
			Number of graduates (bachelors, masters, doctoral) from recognized ocean-based university courses (no./annum)
			Number of certificates issued through approved training courses (no./annum)
			Number of public communications with regard to ESSIM per annum (no./annum)
		Ocean-related services and infrastructure are adequate	Existing infrastructure/required infrastructure by type (ratio)
			Funding provided to ocean-related services per annum ($/annum)
		Ocean-related human health, safety and security enhanced	Number of safety incidents reported by ocean-related industries (by sector and by type) per year (no./annum)
			Number of marine security incidents per year (no./annum)
			Perceived security level
Economic well-being	To contribute to wealth generation through activities related to the ocean system and distribution according to societal objectives	Generate wealth from the ocean by fostering new opportunities and supporting existing opportunities	Annual contribution of ocean sectors to provincial GDP ($/annum; % GDP)
			Real growth per sector per annum (%)
			Genuine Progress Index
			Number and value of new/emerging industries per annum (no.; $/a)
		Access to and distribution of wealth and benefits within coastal communities/Nova Scotia/Canada	Intrinsic value of protected species and MPAs
			Provincial ocean sector tax revenues and royalties/ NS government budget (%)
			State of satisfaction
			Multiplier value (in pilot communities or sectors)
		Efficiency of resource use and ocean space	Costs associated with management activities ($/activity/annum)
			Costs associated with regulatory activities as a percentage of revenue generated per sector (%)
Industrial Capacity and Assets	To support commercial activity and non-commercial uses within the bounds of resource capacity, while	Industrial infrastructure capacity is balanced with resource availability	Fishing fleet capacity/TAC or quota (ratio)
			Percentage licensed fishing capacity working (%)
			Cumulative production vs reserves (oil and gas, aggregates) (units/annum)

HUMAN USE ELEMENT	ESSIM OBJECTIVE	SUB-OBJECTIVE	INDICATORS
	incorporating a culture of resource stewardship		Percentage utilization of communication infrastructure
		Multi-sectoral use is balanced and resource use conflict decreased on the Scotian Shelf	Sectoral footprints (area)
			Number and type of conflicts or incidents (no.; quantitative description)
		Stewardship and best practices are promoted	Number of best practice guidelines developed (no.)
			Amount of effluent discharged directly into the marine environment per annum by type (tonnes/annum)
			No. of birds oiled at sea per annum (no./annum)
Integrated Management Process	To develop institutional arrangements and capacity, and appropriate management strategies and actions that contribute to integrated ocean management	Collaborative planning structures with adequate capacity, which are accessible to community members	Audited budgetary expenditure for operating formal ESSIM management structures ($/annum)
			Budget allocations made by ESSIM stakeholders in order to participate in ESSIM management structures ($/annum)
			Number of personnel hours allocated by collaborating parties for ESSIM activities (hours/annum)
			Extent of participation in formal ESSIM activities
			Presence of a stakeholder register and database that also outlines ESSIM responsibilities and involvement
			Number of key decisions that are made by ESSIM structures (no.)
		Policies, plans, programs and measures applicable to ocean users	Presence of the ESSIM Plan
			Policies and programs relevant to ESSIM
			Presence of operational guidelines and practices for each of the user sectors
			Checklist of required documents that apply to ESSIM management
		Legal principles (international, federal and provincial) and responsibilities implemented	Published review of applicable legislation for ESSIM area (qualitative)
			Number of newly introduced legislative directives per annum that apply to ESSIM users (no.)
			Number of newly introduced legislative directives per annum that apply to ESSIM regulators (no.)
			Resources and activities that arise as a result of newly introduced directives
		Ocean user compliance with the ESSIM Plan and regulator accountability toward the Plan	Number of officially reported incidences of non-compliance per annum (no.)
			Number of successful prosecutions per annum (no.)
			Number of "unofficial" incidences of non-compliance per annum (no.)
			Presence of a monitoring and reporting system
		An effective communication system by which the public and stakeholders are made aware of, and are able to understand, ESSIM in terms of decisions, activities and implications	Presence of a Communication Strategy and Program
			Numbers of stakeholders who receive and read an ESSIM general newsletter (no.)
			Number of official radio and TV, website announcements related to ESSIM activities (no.)
		Adaptive management in response to change	Number of regular formal reviews undertaken to assess ESSIM (no./annum)
			Number of changes to the plan that are made in response to formal review of ESSIM (no./annum)
			Number of changes to the plan that are introduced in response to unforeseen circumstances (no./annum)
			Number and budget of research projects in the ESSIM area by subject (no. and $/annum)

The objectives and indicators presented in the ESSIM Plan are currently under review and are being further tested and refined.

3.0 INTERNATIONAL REVIEW

3.1 Methodology

The first step in the review was to identify regions, countries and institutions that were involved in ecosystem-based marine management, and to determine whether any of them were developing objectives and indicators as part of their management strategy.

Initially, in January 2004, an Internet search was undertaken in using the advanced multiple search engine software, *Copernic Agent Professional* (http:///www.copernic.com 2004). *Copernic* searches existing common search engines on the Web, and presents the results in an interactive format compatible with *Microsoft Word*. Search patterns that were requested included:

- Marine ecosystem-based management;
- Marine ecosystem-based management objectives;
- Marine management Australia;
- Marine management United Kingdom;
- Marine management Europe;
- Marine management South Africa;
- Marine management Canada; and
- Objectives and indicators marine ecosystems.

The results of the search provided preliminary information of which countries and organisations were involved in ecosystem-based marine management. Based on this, environmental, marine management and research organisations that were known to have been involved in ecosystem-based marine management were approached, and e-mail contact made with the relevant individuals. The contact persons were asked for information with regards to initiatives within their organisation, country or region. Information from the various organisations was collected initially in 2004 and updated in 2005.

A preliminary analysis of the information obtained from contact people and from the Internet, indicated which initiatives were involved in the setting of ecosystem and human use objectives (ecological, social, economic and/or institutional) and indicators. An overview of these initiatives was compiled, with particular reference to:

- The background to the initiative, and the approach taken to develop objectives and indicators;
- The outcomes of each initiative to date; and
- An evaluation of each initiative.

For those initiatives that had already developed objectives and indicators, the objectives were compared to those already developed for ESSIM.

3.2 Results

As presented in the previous review report (Walmsley 2004), the results of the Internet search indicated that there are few ecosystem-based marine management programs similar to ESSIM. Most ecosystem-based initiatives focus solely on fisheries and do not take other marine resources or uses into consideration. It is obvious from the websites viewed that the development of objectives and indicators is a relatively new science and there is still uncertainty in its application, despite the recognition of its importance (Walmsley 2004).

Table 3 provides information on the countries or regions, and organisations contacted and the initiatives identified, as well a summary for each initiative.

Table 3 List of countries or regions, organisations, contact people and marine ecosystem-based initiatives.

COUNTRY or REGION & ORGANISATION	INITIATIVE
Australia CSIRO	**Reporting Framework for Ecologically Sustainable Development (ESD) and Fisheries** ESD is a "dynamic concept that recognises the need to integrate the short- and long-term economic, social and environmental aspects of activities and is now enshrined in most fisheries legislation in Australia" (http://www.fisheries-esd.com 2004). The program is focused on fisheries (not other marine resources), but includes a socio-economic component. The objectives and indicators are based on hierarchical "component trees". **North-West Shelf Project** Indicators are being developed for this project, based on the principles of the ESD program. A list of indicators was provided, but no report is currently available. **Ecosystem Indicators of the Effects of Fishing** This project used computer-generated data to test the performance of a range of indicators identified through a literature review. It is not objectives-based.
Australia National Oceans Office	**South-East Regional Marine Plan** The South-East Regional Marine Plan (SERMP) for the marine region around New South Wales and Tasmania was published by the Australian Federal Government in 2004 (http://www.oceans.gov.au 2005). The plan contains regional objectives and actions for implementation, although no indicators have yet been developed. **Northern Regional Marine Plan** The Northern Regional Marine Plan has concluded the scoping phase of developing a marine plan (http://www.oceans.gov.au/North_rmp.jsp 2005). Much of the work includes characterization of the area and understanding key conservation issues. The regional marine plan includes the Torres Strait, which has a separate planning process, outputs and outcomes due to its separate status under the Torres Strait Treaty (http://www.oceans.gov.au/Torres_regional_marine_plan_overview.jsp 2005) No objectives and indicators have been developed.
Australia Great Barrier Reef Marine Park Authority (GBRMPA)	**Key Performance Indicators (KPIs)** The GBRMPA has developed seven high-level KPIs for the management of the park. These record the success of the main foci for the reef, namely reef health, pollution from land-based sources, fisheries, park management, information management, tourism and community participation. **State of the Reef Report** State of the Great Barrier Reef report is published as a living document placed on the Internet and regularly reviewed and updated. It is based on the pressure-state-response model that is commonly used for state of the environment reporting internationally. The GBRMPA does not have an initiative for developing objectives and indicators for integrated management.
Canada Fisheries and Oceans, Pacific Region	**Pacific North Coast Integrated Management Area (PNCIMA)** As part of the Pacific Central Coast Initiative, which was later integrated with the PNCIMA, a preliminary set of Marine Environmental Quality (MEQ) objectives and indicators was developed. Since 2004, the initiative has been placed on hold until the region has developed a scope for the integrated management initiative under the *Oceans Act*. The results of the initiative are presented in the 2004 review (Walmsley 2004), but are excluded in this report due to their uncertain status.
Europe European Environment Agency	**Marine and Coastal Indicators** The European Environment Agency has developed a set of indicators for marine and coastal systems (http://www.eea.eu.int 2004) for State of the Environment reporting. The indicators are not objectives-based.
Europe HELCOM	**Ecological Quality Objectives (EcoQOs) for the Regional Ecosystem Approach for the Baltic Sea** The "ecosystem approach" has recently been adopted by the Helsinki Commission (HELCOM), the Regional Seas management organization for the Baltic Sea, as part of the European Marine Strategy. HELCOM believes that the setting of EcoQOs is an integral part of the ecosystem approach to marine

COUNTRY or REGION & ORGANISATION	INITIATIVE
	management. Thus, a project has been initiated to develop a set of EcoQOs for the Baltic Sea. A methodology has been developed for the setting of EcoQs (http://www.helcom.fi//environment/ecoqo_project/ecoqo.html 2004).
Europe OSPAR	**North Sea Pilot Project** In 2002, the 5th North Sea Ministerial Conference met in Bergen, Norway, and agreed to implement an ecosystem approach to the management of the North Sea through the Bergen Declaration. This included the establishment of a pilot project in 2003 to develop EcoQOs, under the auspices of the International Council for the Exploration of the Sea (ICES) on behalf of OSPAR (http://www.ices.dk/iceswork/ace.asp 2005).
Intergovernmental Oceanographic Commission (IOC) of UNESCO	**Integrated Coastal and Ocean Management (ICOM) Indicators** The IOC, in collaboration with DFO and US National Oceanic and Atmospheric Administration (NOAA), is aiming to promote the development and use of ICOM indicators. A Handbook has been published (IOC 2005), which provides an approach to the development of objectives and indicators for coastal and ocean management.
International Union for the Conservation of Nature (IUCN), World Wildlife Fund for Nature (WWF) and NOAA	**Marine Protected Area (MPA) Management Effectiveness Initiative** In 2000, the IUCN World Commission on Protected Areas (WCPA Marine) and the World Wildlife Fund for Nature (WWF) formed the MPA Management Effectiveness Initiative to develop a guidebook for assessing MPA management effectiveness, based on MPA objectives and indicators. The guidebook provides generic objectives and indicators for MPAs.
New Zealand Ministry of Fisheries and New Zealand National Institute of Water and Atmospheric Research (NIWA)	**Strategy for Managing the Environmental Effects of Fishing** A fairly high-level strategy is being developed of ecosystem-based management of the New Zealand fishery. There is currently no initiative to develop ecosystem-based management objectives and indicators.
UNEP Regional Seas Programmes	**Regional Seas Programmes** The Regional Seas Programmes of UNEP, based on Large Marine Areas, were investigated. Most of the programs are still struggling with the institutional arrangements required for cross-boundary management of seas. Few of the Regional Seas organizations have got to the stage of developing objectives and indicators for ecosystem-based management (with the exception of OSPAR and HELCOM). Management of the regional seas is based on marine action plans, which outline actions required, rather than objectives and targets.
South Africa, Namibia, Angola	**Benguela Current Large Marine Ecosystem Programme** This is a multi-national cross-sectoral initiative by Angola, Namibia and South Africa to manage the living marine resources of the Benguela Current, which flows up the West Coast of Africa. It is funded by the Global Environment Facility (GEF) under its international waters portfolio. The program is chiefly aimed at trans-boundary issues and does not have an objectives and indicators initiative (http://www.bclme.org 2005).
South Africa	**Ecosystem Approach to Fisheries** In December 2002, a workshop was held to introduce and initiate an ecosystem approach to fisheries in South Africa. In 2003, a working group was established. The group is tasked to draft a policy document for presentation to a wider forum of stakeholders. The Benguela Current LME will be used as an example. Objectives and indicators have not been developed.
United Kingdom (UK) – Wales	**Management of the Wales Territorial Sea** The Wales Territorial Sea comes under the auspices of the UK Government. Some work has been done on the options for improving the planning and management of the sea for the Countryside Council for Wales (Cardiff University 2001). No objective initiatives have been undertaken.
United Kingdom OSPAR	**Developing Nature Conservation Objectives for the Irish Sea Pilot** The Irish Sea Pilot has been undertaken to test a proposed new marine nature conservation framework in the Irish Sea (http://www.jncc.gov.uk 2004). It falls under the Regional Seas Programme as part of the Oslo-Paris Commission (OSPAR). Part of the project included developing a trial set of "nature conservation objectives", completed in 2004.
United Kingdom	**Safeguarding Our Seas – A Strategy for the Conservation and Sustainable Development of our Marine Environment** The Strategy (DEFRA 2003) provides a vision for the marine environment for the UK. Principles that

COUNTRY or REGION & ORGANISATION	INITIATIVE
	underpin the policy are presented and policies for each of the marine sectors outlined.
United States NOAA Marine Fisheries Advisory Committee	**Strategic Guidance for Implementing an Ecosystem-Based Approach to Management** A strategic planning exercise has been undertaken by the NOAA/MFAC to identify issues that must be addressed before meaningful ecosystem-based fisheries management is feasible. The resultant strategy (Busch *et al.* 2003) is based on the setting of goals and objectives as targets in management. The process has not yet got to the stage of developing objectives and indicators, although this is specified as one of the action requirements.
United States and Canada Gulf of Maine	**State of the Gulf of Maine** One of the goals of the Gulf of Maine Council is to help identify and track a set of regional environmental indicators and produce a "State of the Gulf" report. A draft set of regional indicators was developed in January 2004. These are currently being developed further and tested. The indicators are not objectives-based.
United States	**Bering Sea Ecosystem Program** This program was an effort to improve communication and co-ordination amongst stakeholders in the Bering Sea area. The final report provides recommendations for future action, but does not include objectives and indicators (Alaska Office of the Governor 2003).

Of the 23 initiatives identified, only nine had either developed or were in the process of developing objectives and indicators for marine ecosystem-based management, and were available for review. These include:

- Reporting Framework for Ecologically Sustainable Development (ESD) and Fisheries, Australia;
- North-West Shelf Project, Australia;
- South East Regional Marine Plan, Australia;
- Ecological Quality Objectives for the Regional Ecosystem Approach for the Baltic Sea, HELCOM;
- Developing Nature Conservation Objectives for the Irish Sea, United Kingdom;
- North Sea Pilot Project, OSPAR;
- Gulf of Maine Indicators, Gulf of Maine Council on the Marine Environment, Canada and the United States;
- IOC ICOM Objectives and Indicators, IOC of UNESCO; and
- MPA Management Effectiveness Initiative, IUCN/WWF/NOAA.

Each of these initiatives and their approaches to developing objectives and indicators are described briefly below.

3.2.1 Reporting Framework for Ecologically Sustainable Development (ESD) and Fisheries, Australia

In 1990, the Commonwealth Government of Australia embarked on a process of defining ESD and established nine ESD Working Groups, including one on fisheries (SCFA and FRDC 2001). The reports of these groups provided the foundation for the National Strategy for Ecologically Sustainable Development (NSESD), which was endorsed by all Australian state and commonwealth governments in 1992. Since 1992, ESD has become a major objective within most fisheries acts in Australia, and thus management agencies are accountable for achieving these objectives (SCFA and FRDC 2001). An important component of this accountability is the measurement and reporting of progress against the objectives of ESD.

The Standing Committee on Fisheries and Aquaculture (SCFA), which comprises the heads of state, territory and commonwealth fisheries agencies, has embarked on a program to develop a nationally agreed system for ESD reporting on Australian fisheries and aquaculture. They have developed a reporting framework, tested through a series of case studies (SCFA and FRDC 2001). An important component of the development process was stakeholder involvement through the formation of the SCFA Reference Group, which included representatives from all major stakeholder groups, including government, commercial industry, indigenous interests, recreational fishing, aquaculture, the Fisheries Research and Development Corporation (FRDC), environmental groups and experts in social and economic research. The resultant framework took into account the Food and Agriculture

Organisation report on sustainable fisheries, previous work done on ESD, and reporting arrangements already in place.

The framework includes a set of high-level, core objectives, under which fall several conceptual objectives for ecological and human well-being (Figure 3).

Core Objectives:

- To protect biodiversity and maintain essential ecological processes
- To provide effective legal, institutional and economic frameworks for ESD;
- To enhance individual and community well-being by following a path of economic development that safeguards the welfare of current and future generations.

Ecological well-being			Human well-being		
Retained species	**Non-retained species**	**Other environmental impacts**	**Indigenous well-being**	**Community/ National well-being**	**Governance**
To manage the take of retained species within ecologically viable stock levels by avoiding overfishing and maintaining long-term yields	To manage the fishery in a manner that does not threaten biodiversity and habitat via the removal of non-retained species (including protected species and ecological communities) and manage the take of non-retained species	To manage the impacts of and on fishing such that only acceptable impacts occur to functional ecological relationships, habitat and processes.	To satisfy traditional fishing needs, cultural and economic development and sustainability of indigenous communities	To contribute to community, regional and national well-being, lifestyle and cultural needs.	To ensure that ESD principles are underpinned by legal, institutional, economic and policy frameworks; To allocate the resources to maximize or optimize community benefits.

Figure 3 Conceptual framework for ESD of Australian fisheries (SCFA and FRD 2001).

The conceptual objectives have been summarised into eight reporting components, including:

- **Contributions to ecological well-being:**
  1. Retained species;
  2. Non-retained species;
  3. Other environmental issues;

- **Contributions to human well-being:**
  4. Indigenous community well-being;
  5. Community well-being;
  6. National social and economic well-being;

- **Ability to achieve:**
  7. Impact of the environment on the fishery;
  8. Governance.

The eight reporting components have been further broken-down through the use of "generic component trees". Each component tree breaks down the core objectives into sub-components for which operational objectives can be developed. The eight generic component trees for the wild capture fishery developed by the SCFA are shown in Figures 4 to 11 (SCFA and FRDC 2001). The generic component trees can be tailored to suit each fishery to which ESD reporting is applied, expanding some sub-components and collapsing or removing others (SCFA and FRDC 2001). The component trees shown here have been applied directly to wild fish fisheries, but similar trees for aquaculture have been developed to suit the industry (http://www.fisheries-esd.com 2004).

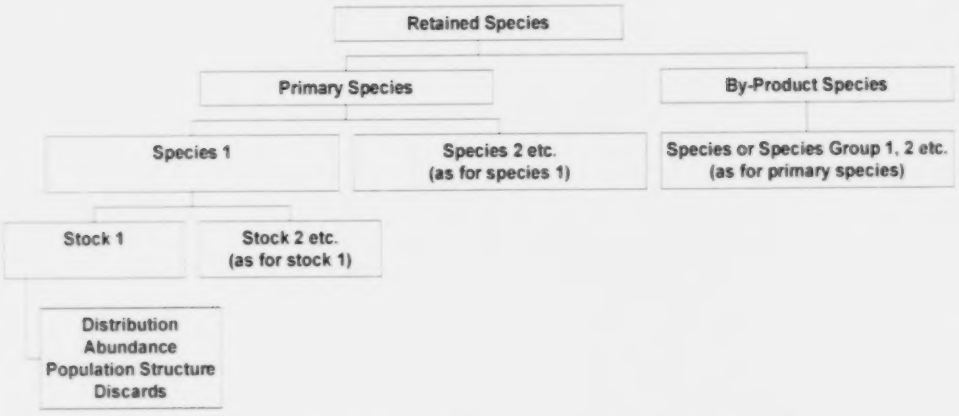


Figure 4 **Issues related to retained species in a fishery.**

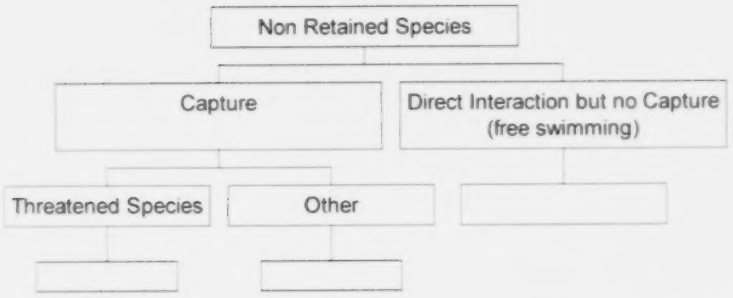


Figure 5 **Issues related to non-retained species in a fishery.**

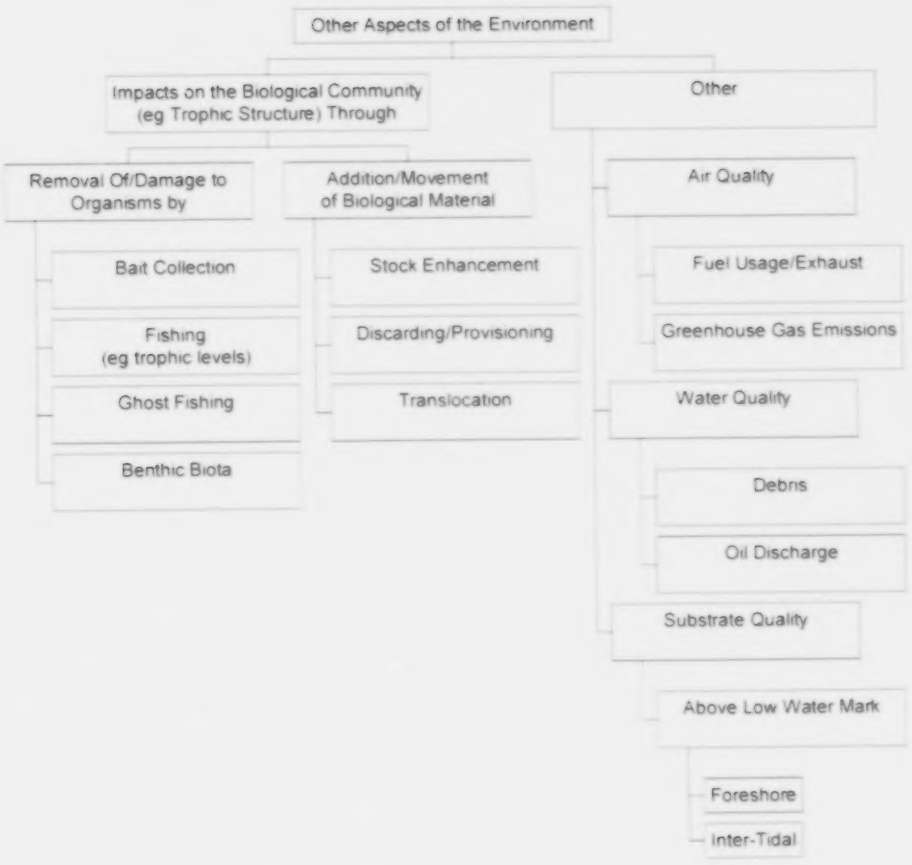


Figure 6 **Issues related to the general environmental impacts of a fishery.**

Figure 7 **Contribution of the fishery/industry to indigenous well-being.**

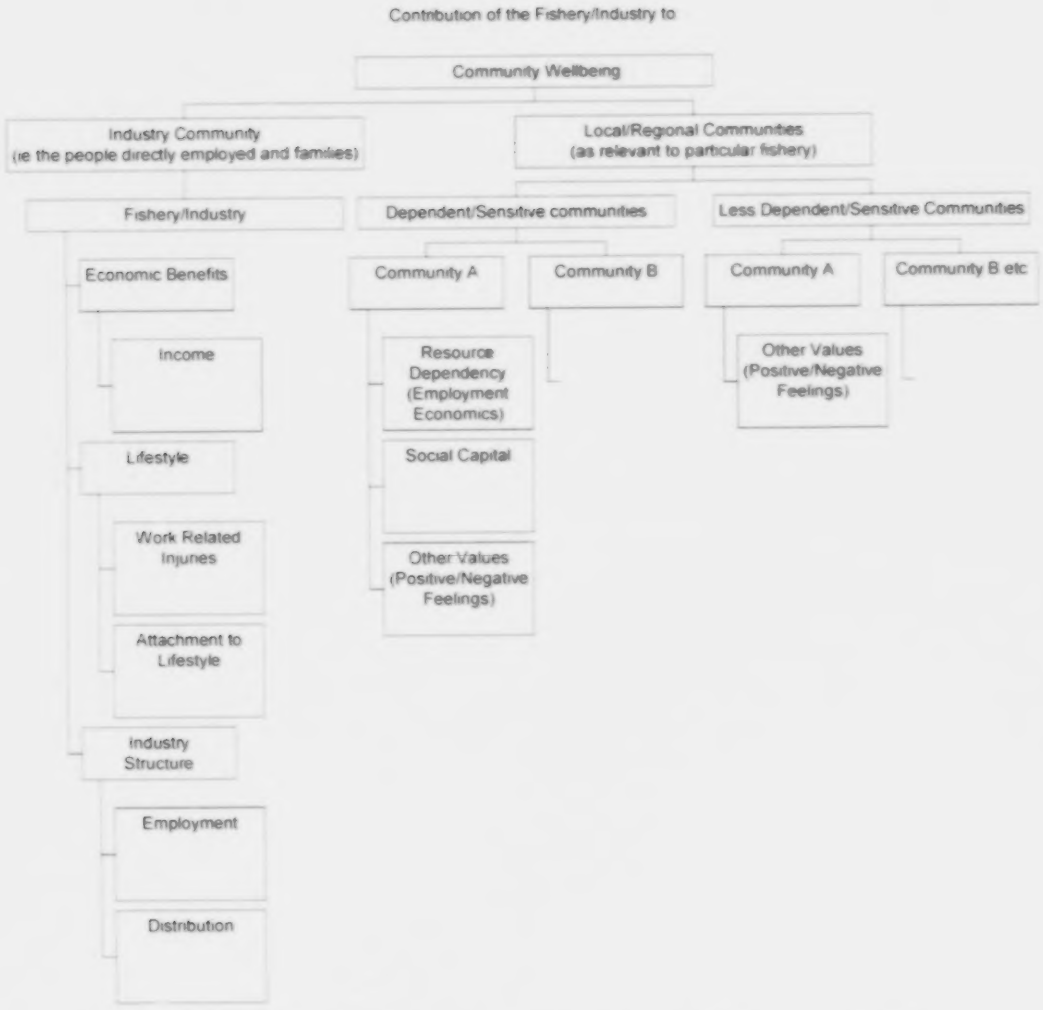


Figure 8 Contribution of the fishery/industry to community well-being.

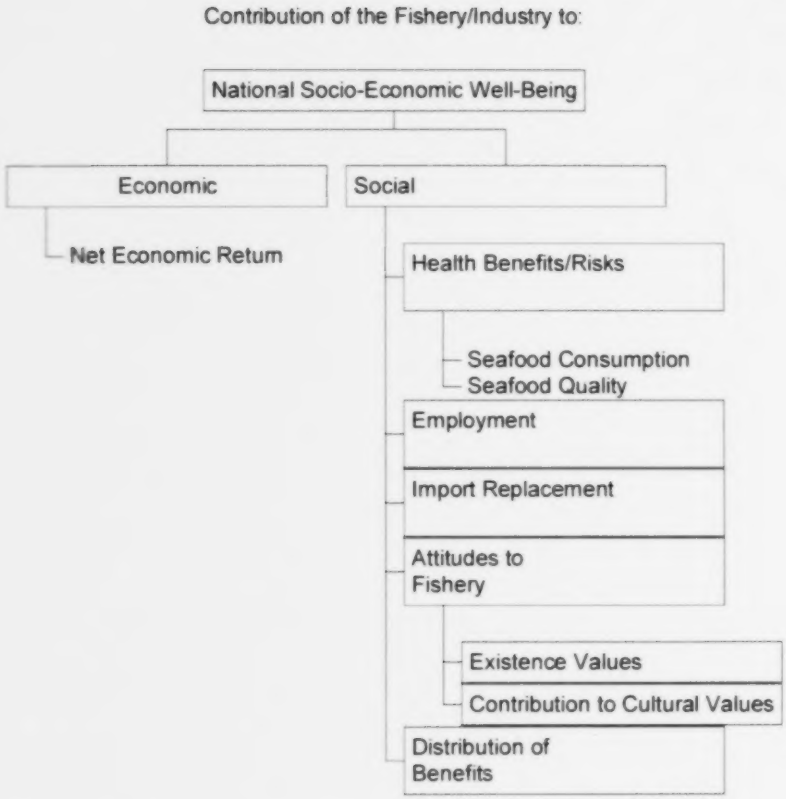


Figure 9 Contribution of the fishery/industry to national socio-economic well-being.

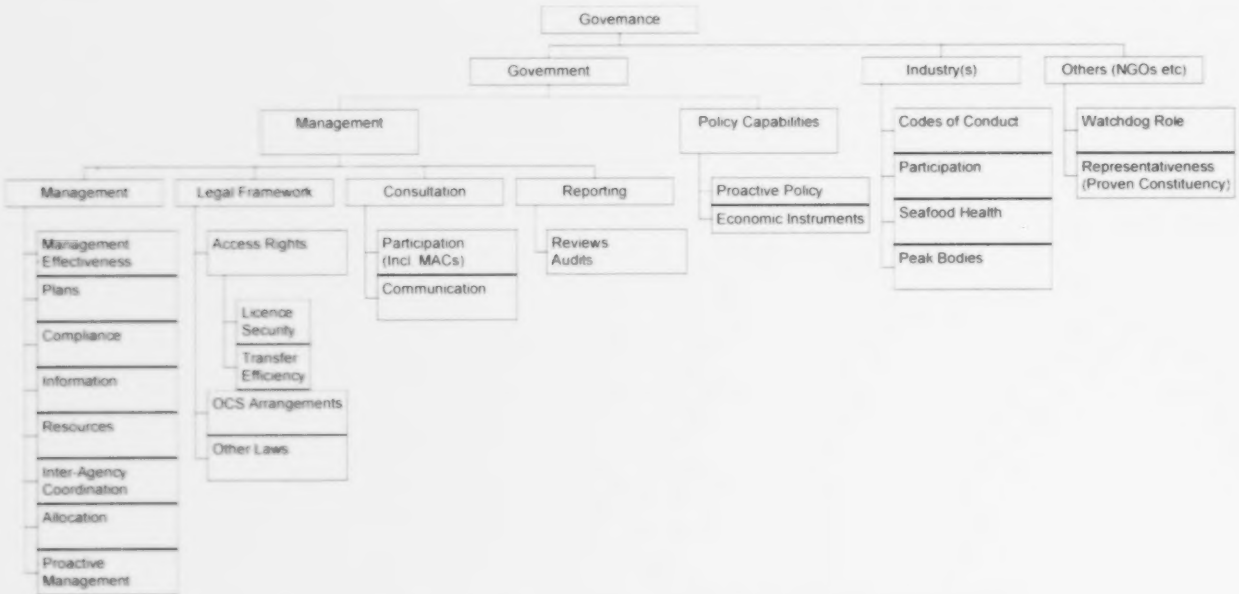


Figure 10 Issues related to governance of the fishery/industry.

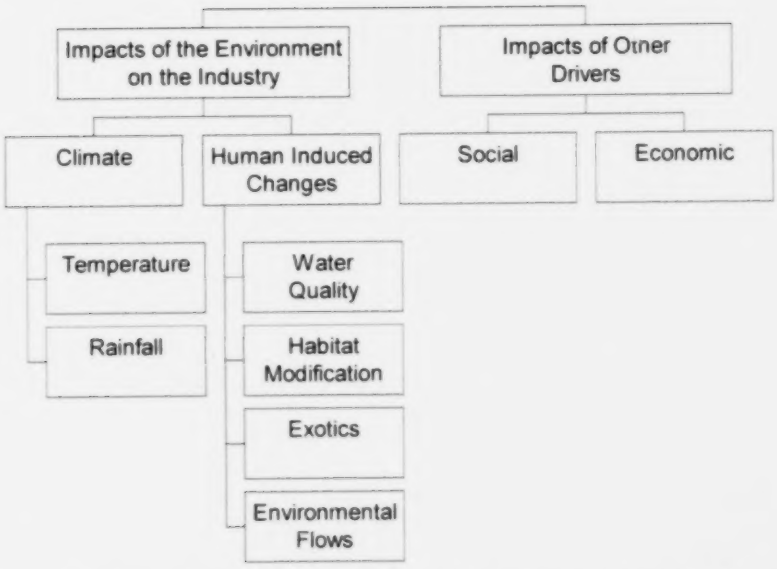


Figure 11 Impacts of the environment and other issues on the fishery/industry.

For each of the lower level sub-components, a risk assessment is undertaken in order to determine the appropriate level of management response and monitoring required (http://www.fisheries-esd.com 2004). Only the components of "high risk" are reported on by developing operational objectives, indicators and performance measures. In addition, the management responses necessary to achieve acceptable performance are outlined.

The ESD framework is essentially an issues-based framework for reporting on ecosystem-based management. It provides a methodology for assessing which issues (components) provide the greatest risk to the sustainability of the ecosystem. These are then further developed so that each component has related operational objectives and indicators for reporting.

Several characteristics of this initiative should be highlighted:

- The ESD project has established a commonly understood terminology, which is used consistently throughout the project. Because the development of objectives and indicators is a relatively new science, the terminology used is still fairly fluid, and will change over time. Defining a set of frequently-used terms assists in overcoming some of the uncertainty and improves communication.
- The framework was developed through a stakeholder participation process that included a wide range of stakeholder interests. In establishing a system that will eventually require stakeholder co-operation, it is important that this is obtained at the outset, providing opportunity for stakeholder input from the start.
- The framework is fisheries-based and does not take multiple uses of the marine resources into account. This does not mean that the framework cannot be further developed to include other resource users.
- The ESD framework includes ecological, economic, social and governance objectives. It does not concentrate on one aspect but, in keeping with the philosophy of sustainable development, incorporates and balances all of these.
- The framework provides a complex, scientific method of identifying important issues, which might be just as easily identified by a less rigorous approach.

3.2.2 North-West Shelf Project, Australia

Western Australia's North West Shelf (NWS) contributes $6 billion to the national economy and is an economically significant land and sea region in Australia (CSIRO and DEP 2002). It produces the majority of Australia's

domestic and exported oil and gas. Other major industries operating on the shelf include commercial fisheries, aquaculture (especially pearl farming), salt production, shipping (associated with the transport of oil, gas, salt and iron ore) and a rapidly expanding tourism industry (CSIRO and DEP 2002). With the rapid growth of marine industries across a range of sectors, the potential for conflict between different uses of the marine environment is increasing. Also these major industries operate in a region recognised for its rich marine biodiversity. From the experience elsewhere in the world, environmental quality and the ecological sustainability of industries, with their associated employment and wealth generation, may be compromised at some point unless development occurs in an integrated and ecologically-based management framework (CSIRO and DEP 2002).

In recognition of the rapidly increasing development pressures on the poorly understood marine environments of the North West Shelf, the Western Australian Government, through the Department of Environmental Protection (DEP) and CSIRO is providing $6.1 million in new resources to undertake a marine environmental management study of the North West Shelf (http://environ.wa.gov.au/nws/ NWSJEMS_Outline.html 2004).

The principal objective of NWS Joint Environmental Management Strategy is to develop and demonstrate practical and science-based methods that support integrated regional planning and management of marine ecosystems to achieve ecologically sustainable development. The two key aims are to (CSIRO and DEP 2002):

- Compile, extend and integrate the scientific information and understanding of the marine and coastal ecosystems of the NWS; and
- Develop and demonstrate practical, science-based methods that support integrated regional planning and multiple-use management for ecologically sustainable development of marine ecosystems.

The NWS Study is a large-scale program with several major projects, including (CSIRO and DEP 2002):

- Biophysical and management setting;
- Community consultation;
- Information access and inquiry;
- Ecosystem and inventory of human activities;
- Dynamics of the ecosystems and human impacts; and
- Development scenarios and management strategy evaluation (MSE project).

The MSE project uses objectives and indicators to integrate the results of the other projects of the North West Shelf Joint Environmental Management Study into a management context. The aims of the MSE project are to:

- Evaluate and recommend a range of environmental indicators and performance measures for ESD of the NWS regional ecosystem;
- Develop integrated models of the NWS regional ecosystem and human impacts for use by industry sectors and management agencies; and
- Evaluate strategies for regional zoning, monitoring and adaptive multiple-use management of the NWS regional ecosystem.

The MSE framework that was developed for the NWS is shown in Figure 12. The framework includes a model of the natural system, a model of each of the important sectors of human activity, and a model of how decisions are made, including monitoring activities. All these elements were included in a computer model of the system.

For each of the management issues identified in the course of the NWS Joint Environmental Management Study, the following are specified for MSE:

- *Management objectives* expressed in terms of their intended impact on the regional ecosystem and/or local environment;
- *Management strategies* for achieving specified objectives (including identification of feasible control variables, monitoring programs and feedback mechanisms, as well as specification of decision rules); and

Indicators and performance measures (from the biophysical model) and *indicators* (from management observation and monitoring) for assessing how well management objectives have been achieved.

The various management strategies are evaluated by comparing performance measures and indicators from model simulations. Currently there is no complete list of objectives, strategies, indicators and performance measures available, however, the indicators being considered for inclusion in the model are summarized in Figure 13 (Beth Fulton, CSIRO Marine Division, Hobart, Australia, *pers. comm.* 2004).

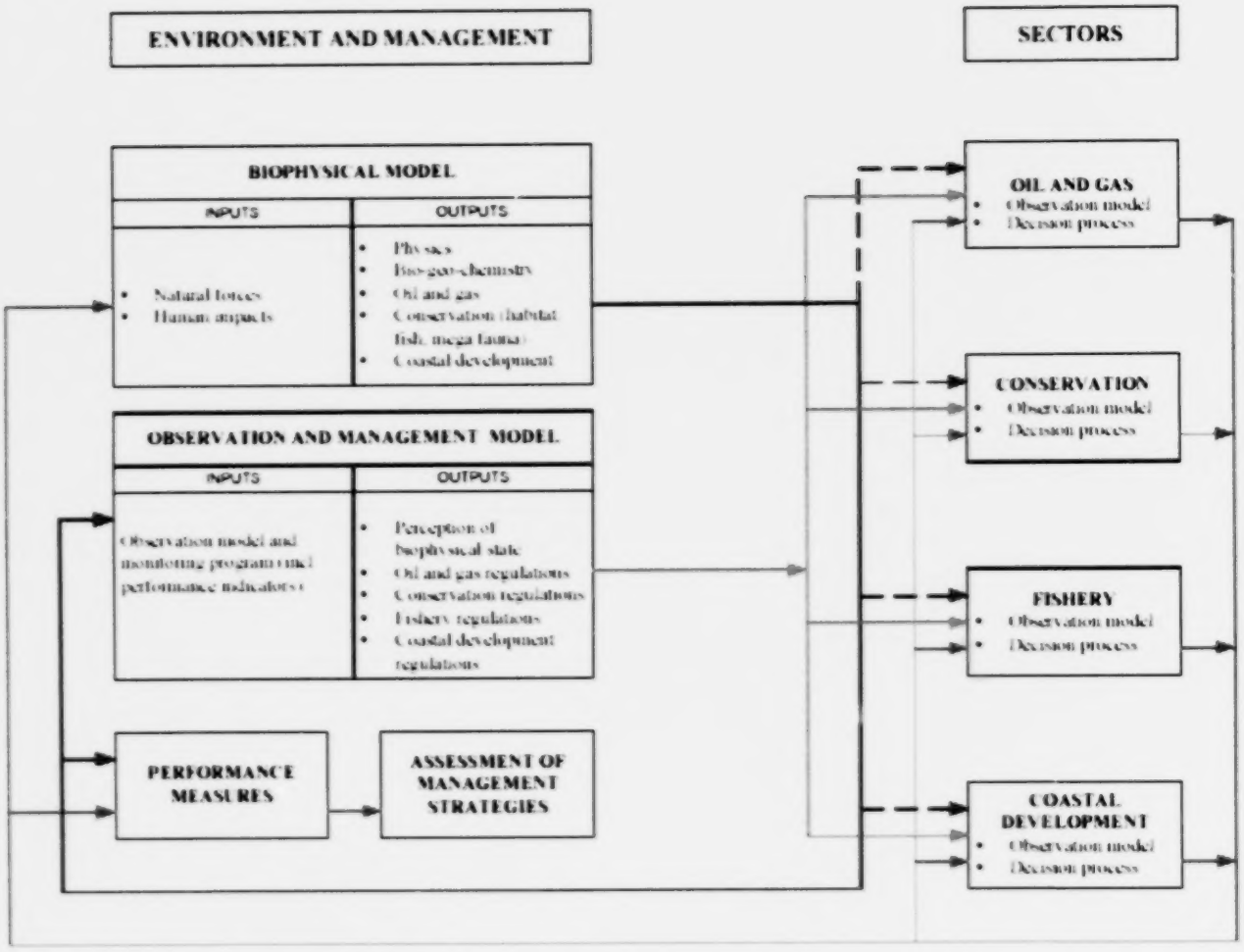


Figure 12 **North West Shelf Project MSE framework (CSIRO and DEP 2002).**

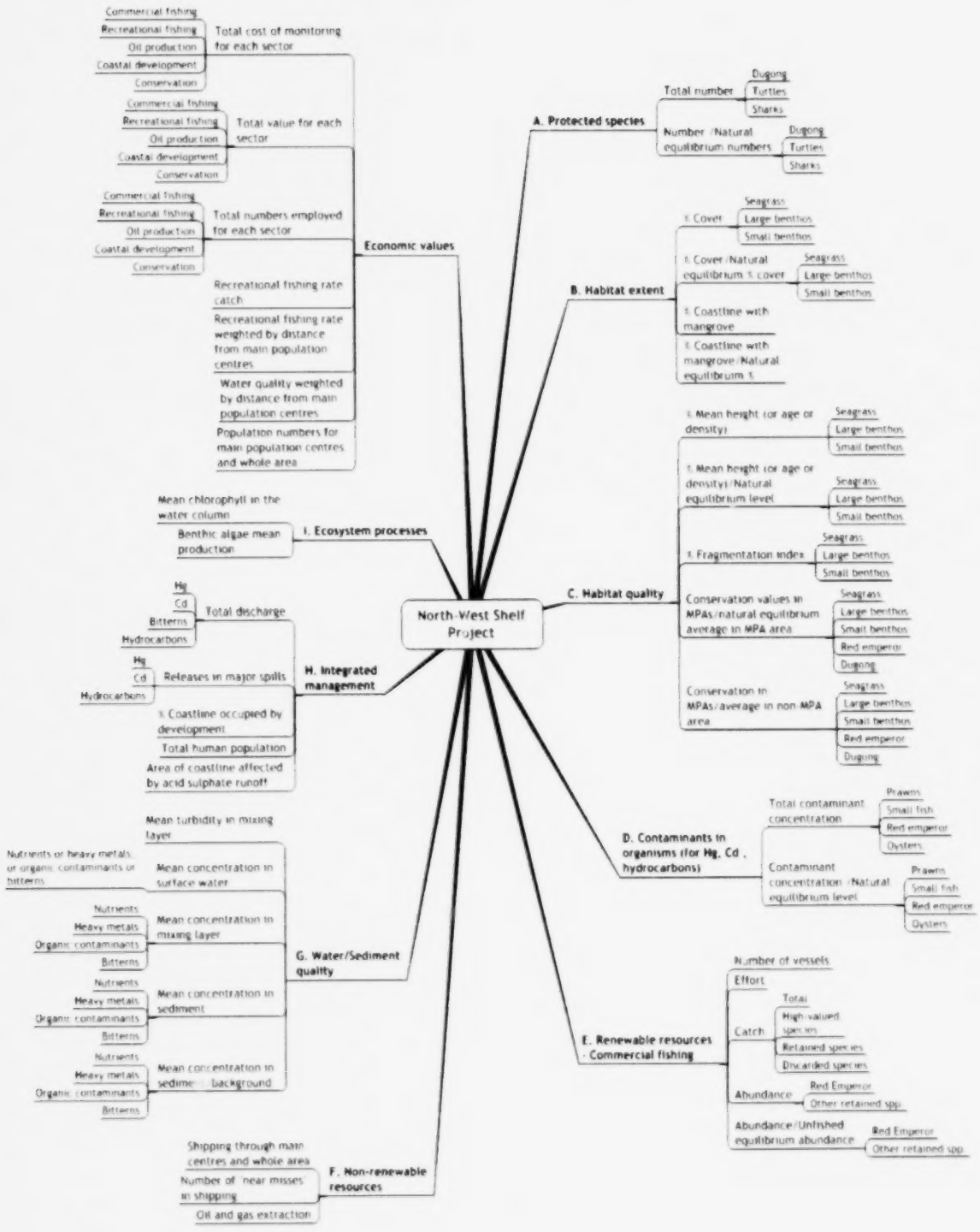


Figure 13 **Indicators used for the NWS MSE Project (Source: Beth Fulton, CSIRO Marine Division, Hobart, Australia, *pers. comm.* 2004).**

The objectives and indicators project for the North West Shelf comes under the auspices of the MSE project. The project models the system and tests the indicators using simulated data. In essence the model provides a tool for scenario modelling.

The MSE model is useful in providing the link between management actions required and the indicators that measure success or failure. This critical link is often missing in indicator development projects (*e.g.*, state-of-the-environment reporting). Although ecosystem-based objectives and indicator projects try to make sure the links are explicit, the connection is more often linear, without taking cognizance of inter-relationships and the complex behavior of the system.

3.2.3 South East Regional Marine Plan

The South East Marine Region covers about 2 million km^2 of water surrounding Victoria and Tasmania, the waters around the Macquarie Island to the south, and the ocean off the New South Wales far south coast and Eastern South Australia (NOO 2004). There are more than 275,000 jobs that depend directly or indirectly on marine-based industry in the region, in fishing, petroleum, shipping, shipbuilding, port-based activities and tourism. In this region alone, these industries contribute more than $19 billion a year to the country's economy. It is also blessed with a rich biodiversity and unique natural habitats (NOO 2004).

The South East Regional Marine Plan has been developed in accordance with the goals, principles and processes established for regional marine planning under *Australia's Ocean Policy*. It aims to provide for development that improves quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends. The Plan reflects the Australian Government's commitment to:

- The ecologically sustainable development of marine industries;
- Co-operative and inclusive marine management;
- Community and Indigenous participation in marine management; and
- The conservation of marine biodiversity.

The Plan has been developed by the Australian Government in consultation with South-East State governments, industry representatives, indigenous groups, marine communities and others with an interest in the marine environment. It outlines the way in which management of the area will be improved through Government and stakeholder co-operation and is designed to improve existing management arrangements through objectives-based management.

The South-East Regional Marine Plan specifies nine regional objectives and 93 actions required to implement the objectives (Table 4). Also included in the plan are the positive outcomes expected in the region once the objectives have been met.

Table 4 Objectives, actions and outcomes of the South-East Regional Marine Plan

OBJECTIVE	KEY ACTIONS	OUTCOME
Ensure that all ocean uses are ecologically sustainable	• Design a monitoring and reporting regime to determine the ecological, social and economic health of the Region; and • Conduct a risk assessment to identify the combined effects of our activities.	A new way of understanding and measuring the ecosystem as a whole that provides a backdrop for management of resources for individual users. This will allow us to confirm that the entire range of marine resource use, when considered jointly, is ecologically sustainable.
Protect, conserve and restore the Region's marine biodiversity, ecological processes, and natural and cultural marine heritage	• Develop a system of representative marine protected areas (MPAs) for the Region, including candidate options for two areas (Murray and Zeehan), that cover more than 40,000 km^2 • Improve our knowledge of marine ecosystems, including better mapping of the seafloor and its habitats, e.g., seamounts and canyons • Do targeted work on key threats to the Region's marine biodiversity, e.g., declining water quality and introduced marine species	A set of representative and important habitats, that support marine biodiversity, will be protected and the impacts of priority threats to these ecosystems will be minimized. We will also be able to measure the health of the oceans in the Region to see whether management is working.
Increase long-term security of access and certainty of process for existing and future marine-based industries	• Review marine-related laws and regulations that apply in the Region to see where improvements can be made; • Ensure industry representation and participation in marine management, e.g., through membership of an advisory group for the Region and participation in specific projects such as identifying candidate marine protected areas • Provide a clear process for future management planning and development that considers existing access and use.	Industries can actively manage and plan for future growth with access to better information and advice about management requirements. They will also have opportunities to check that their current and future needs are being considered in the development of management actions in the Region.
Promote economic development and job creation in the Region consistent with ecologically sustainable development	• Improve our understanding of key economic issues facing marine industries, such as increasing operational and development costs, overcapitalization, and internationally competitive markets; • Promote existing best practice and innovation in marine-based industries, such as improvements to gear technology; • Anticipate and develop consistent responses to emerging and future issues, e.g., decommissioning of oil and gas platforms and increasing vessel sizes • Pilot a regional tourism trail based on the marine environment, seafood and culture.	Support for marine-based industries to capitalize on their investments and further refine their activities to introduce innovative technology and explore new markets. Also achieve recognition of recent advances in industry operations to promote stewardship and self-management, e.g., codes of conduct.
Integrate management of access, allocation, conservation and use of marine resources to ensure fairness and accountability to the community and all users	• Efficiencies in planning and spatial management across sectors, e.g., marine protected areas and fisheries closures • Establish a clear process for addressing cross-sectoral issues, including agreed approaches to multiple-use management in the Region • Regular reporting and review procedures incorporated in a performance assessment system.	A coordinated approach to marine management in the Region that is simple, well understood and that recognizes the needs of all users and the community. Over time, we will have a consistent and streamlined reporting system to check on the success of our management actions and increase accountability.
Increase knowledge and understanding of the Region to improve our capacity to pursue ecologically sustainable development	• Improved co-ordination of research effort and the development of new research partnerships, e.g., between industry and government • Make information available to all on a central web-based Oceans Portal • Report on the effectiveness of management actions and establish a way of adapting management that is based on risk assessment.	More and better coordinated science will be conducted in the Region, leading to improved evidence-based decision making.

OBJECTIVE	KEY ACTIONS	OUTCOME
Enhance community and industry stewardship and understanding of the values and benefits of the Region and involve them in its management	• Implement a marine education strategy that includes teaching packages for schools • Support the establishment of a Marine Discovery Centre Network • Establish a stakeholder advisory group to provide ongoing industry, community and expert participation in management of the Region, including implementation of key actions and future reviews of the Plan.	Communities will be informed about the importance of managing our marine ecosystem to promote responsible and wise use of the marine resources in the Region and build their capacity to be involved in management. Stewardship will be encouraged through recognition of, and opportunities for, communities and industries that take responsibility for marine management in their area.
Involve Indigenous communities in management of the Region in a manner that recognizes and respects their rights, custodial responsibilities, contributions and knowledge	• Build capacity of communities to participate in management through the development of Sea Country Plans such as the Maar Sea Country Plan developed in collaboration with the Framlingham Aboriginal Trust and Winda-Mara Aboriginal Corporation • Look for opportunities for Indigenous participation in commercial activities in the Region, e.g., commercial fishing.	Support Indigenous communities to take an active part in marine resource use and management in the Region.
Take into account in decision making the needs, values and contributions of the community and industry, the national interest and international obligations relevant to the Region	• Establish an agreed process that provides for consistent and inclusive decision making across Australian Government agencies • Work with South-East State governments to explore arrangements that lead to co-ordinated oceans management in the Region, e.g., links between estuarine and ocean management • Provide public reports on the Region, including the health of the ocean and the well-being of the communities that depend on the ocean and the economic benefits provided by marine resource use.	A more strategic co-ordinated approach to marine management in the Region.

The South East Regional Marine Plan is elegant in its simplicity. The objectives have been defined based on the needs and requirements of stakeholders, as well as current issues of the area. The plan specifies its commitment to adaptive management and the structure is such that change can easily be accommodated. However, the Plan does not include an integrated reporting system and the National Oceans Office has commissioned a project to identify and evaluate existing performance assessment systems in the Australian Government to determine which are relevant to the South-east Marine Region. The review includes information on scale, scope, objectives, indicators, and reporting cycles. This information will be used in the further development of the Adaptive Management Framework and performance assessment system to ensure that where possible the framework builds on and enhances work already being done to assess performance in the Region (NOO 2004).

3.2.4 Ecological Quality Objectives for the Regional Ecosystem Approach for the Baltic Sea, HELCOM

In June 2003, the Joint OSPAR (Oslo-Paris Commission) and HELCOM (Helsinki Commission) Ministerial Meeting adopted the ecosystem approach to marine management through the Bremen Ministerial Declaration. It was envisaged that this approach would (http://www.helcom.fi 2004):

- Be based on an existing management plan, setting the desired future conditions through interactive planning sessions with a variety of stakeholder groups;
- Incorporate current existing data with new research to develop ecologically-based concepts and techniques to achieve the desired conditions; and
- Facilitate the evaluation of management outcomes and setting of future policy goals.

One of the initiatives in the implementation of ecosystem-based management by HELCOM is the development of ecological quality objectives (EcoQOs) for the Baltic Sea (http://www.helcom.fi 2005). HELCOM's overall objective, as described by the Convention (HELCOM HOD 13/2003, Minutes of the Meeting, Annex 3) is to: *restore and protect the ecosystem of the Baltic Sea thereby obtaining a sustainable balance between human activities in river basins and in the open sea and the requirements of healthy aquatic ecosystems.* According to HELCOM (2003), the ecosystem approach and the development of EcoQOs will require a holistic approach, incorporating future priority activities of HELCOM in order to guide future research and to help achieve the objectives set out by the Convention (HELCOM 2003). The project is being carried out in close co-operation with the Contracting Parties and stakeholders, specifically HELCOM groups and task forces. It is currently in the second phase of development and EcoQOs already established are being revisited in the light of new developments under the European Marine Strategy (http://www.helcom.fi 2005).

The draft EcoQOs for the Baltic Sea are presented in Table 5.

Table 5 Draft EcoQOs for the Baltic Sea

STRATEGIC GOAL	PROPOSED OPERATIONAL OBJECTIVES	INDICATORS
Eutrophication		
Public: A functioning ecosystem without the harmful effects of excess nutrients. Technical: Reduce eutrophication in order to restore ecological balance within the Baltic Sea and to ensure a functioning marine ecosystem	1. Determine the regional thresholds for improving water clarity which corresponds to meaningful responses in biotic structure and energetic change.	• Secchi depth or other proxy measure for light attenuation • Phytoplankton chlorophyll *a*, and/or pigment concentration • Changes in phytoplankton community structure (percentage of taxonomical groups) • Changes in either desirable or undesirable fish species manifested as fish kills and niche substitution at multiple trophic levels.
	2. No oxygen depleted areas in shallow coastal areas during ice free season 3. There should be no chronic community changes in economically important AND among trophodynamic important benthic (bottom dwelling) assemblages of organisms as a result of oxygen depletion, where it should not occur naturally.	• Species diversity supportive of resilient return to energetic exchanges following a hypoxic event. • Winter concentrations of nutrients Oxygen depletion in shallow waters: • Hypoxia and hydrogen sulphide production • Macrozoobenthos and fish community structure and composition • Changes/kills in benthic organisms • Density of sensitive species • Littoral community composition
	4. Depth range of water plants returned to regionally defined levels. 5. No visible arrivals of opportunistic algae at reference beaches where it did not appear before the 1970s. e.g., green pin-cushion algae (*Cladophora*) or sea lettuce algae (*Enteromorpha*). 6. Bladder wrack (*Fucus vesiculosus*) restored in areas where it has disappeared.	• Phytobenthos (e.g., Bladder wrack - *Fucus vesiculosus*) - depth of maximum abundance - maximum depth of occurrence • Biomass and ratio of biomass of perennial species • Filamentous macro algal mats (e.g., frequency of occurrence)

STRATEGIC GOAL	PROPOSED OPERATIONAL OBJECTIVES	INDICATORS
	7. No exceptional massive algal blooms. Toxic and/or harmful phytoplankton, including blue-green algae, are not to dominate the regionally defined disturbance regime. (e.g., the system is capable of responding to pressure/state changes without manifesting in massive bloom conditions).	• Visible mass accumulation of microalgal species at reference beaches Harmful algal blooms • Frequency and extent of HAB species (algae and cyanobacteria); toxins detection in algal mass (microcystin, saxitoxin, nodularin, DSP toxins)
Hazardous Substances		
Public: Toxic substances shall not affect the health of marine organisms and thus pose a risk to humans Technical: Marine environment which does not cause irreversible changes in the functioning of the ecosystem and human use	1. Concentrations of hazardous substances in the Baltic Sea near background values for respective eastern Baltic and western Baltic levels of naturally occurring substances and close to specifically defined threshold levels for man-made substances. 2. Toxic substances shall not cause sub-lethal nor intergenerational or transgenic effects to the health of marine organisms 3. Toxic substances shall not cause reproductive disturbances in marine organism populations, including humans and birds as marine dependent species). 4. All fish caught in the Baltic Sea shall be suitable for human consumption. 5. An ecosystem with inertial capacity to mediate acute dosage events and cycling capacity to render chronic substance input inert (traps in biologically unavailable sediment or conversion /detoxification by microbes produced specifically to co-occur with effluent streams). 6. Concentrations of man-made radioactivity in the Baltic Sea ecosystem as low as possible and causing risk neither to humans nor the natural systems sustaining human, plant and wildlife populations.	• Organic contaminant concentration (e.g., PCBs, DDTs, TBT, dioxins, pesticides, algal toxins) in selected fish, shellfish and seabird eggs (bioaccumulation) • Organic contaminant concentration (e.g., PCBs, DDTs, TBT, dioxin, pesticides, radionuclides) in sediments under different conditions. Histopathology: • Endocrine disruption (imposex, intersex, vitellogenin, embryo sex ratio, reproductive success, chromosomal aberrations in gonads) • Biomarkers • Heavy metal concentration in selected fish and invertebrates (bioaccumulation)

STRATEGIC GOAL	PROPOSED OPERATIONAL OBJECTIVES	INDICATORS
Over-fishing		
Public: An ecosystem with healthy and functioning fish communities (that provide sustainable environmental, social and economic conditions) Technical: Ensure sustainable exploitation of living aquatic resources that provide sustainable economic, environmental and social conditions.	1. All stocks managed under a long-term management plan and well within safe biological limits (including non-assessed species). Those at present below safe biological limits restored. 2. Impact of fishing practices should be minimized to habitats and non-target species populations (e.g., by-catch of marine mammals & sea birds). 3. Healthy fish communities 4. No changes in fish population structure.	• Spawning stock biomass of commercial fish species • Fish production targets should be agreed to ensure ecosystem maximum sustainable yield e.g., multi species F-target, including targets on sustainability • Changes of the size distribution of the fish • Regionally calibrated fish and aquaculture species disease database as part of an early warning system • CPUE (Catch Per Unit Effort) of fish • Changes in fish community and by catch community structure
	5. The Baltic Sea will be a region where fisheries and aquaculture activities are practiced sustainably and managed responsibly to ensure a healthy marine ecosystem. 6. The production of wild salmon should gradually increase to attain at least 50% of natural production capacity of every individual river before 2010, this in order to achieve a better balance between wild and reared salmon.	• Genetic "pollution" of wild stocks • Infections of parasites and disease • Medicine and chemicals, persistence in an aquatic environment and biological effect of their presence. • Length and maturity at age
Habitats and biodiversity		
Public: A resilient ecosystem that has a sufficient number and connectivity of habitats ensuring healthy species composition and maintained diversity Technical: A Baltic Sea marine environment that maintains a diversity of flora and fauna at all trophic levels and is thereby resilient to disturbance.	1. Minimize the introduction of non-native species, especially from ship mediated introductions.	• Changes in abundance, biomass and distribution of native species.
	2. A sufficient number, size and network of coastal and marine BSPA (Baltic Sea Protected Areas) to ensure the preservation of: natural coastal landscapes within the Baltic Sea; natural ecosystems and processes ensuring long-term interconnectedness between areas; and protect declining / endangered species 3. Restored species supporting climax communities in areas where they have disappeared, e.g., eelgrass meadows (*Zostera*), bladder wrack beds (*Fucus*) and mussel beds (*Mytilus edulis*)	• Physical disturbance of shoreline and coastal water zone. (e.g., habitats disappear, nesting sites disturbed or disappear, obstruction of migratory corridors, fragmentation, shoreline disturbance, stagnation, turbidity) • Presence and extent of threatened biotopes and biotope complexes (cf. HELCOM Red Data Book)
	4. Healthy viable populations of top-predators: mammal populations, seabirds, fish (salmon, trout, cod) 5. Wide knowledge of the structure and composition of marine food-chains with clear identification of Apex predators (including humans).	• Ratio of R to K specialists (e.g., opportunistic quickly reproducing populations with no constraints versus those kept in check by carrying capacity limits and co-evolved ecosystem processes) • Seal population trends

The EcoQOs for the Baltic Sea have developed significantly between 2004 and 2005. The framework is of interest to ESSIM from several aspects, including:

- The framework is essentially an issues-based framework, based on developing EcoQOs for those issues that are considered important for the sustainability of the system. It is interesting to note that both public and technical strategic goals are provided for each issue of concern.
- The Baltic EcoQOs project, by definition, does not take socio-economic and governance issues into consideration. That is, social, economic and governance objectives are not developed within this framework.
- The success of developing indicators is based on the success of merging the "top-down" approach with the "bottom-up" approach. This will require ensuring that scientists and managers not only talk the same language, but also agree on what is important for ecosystem-based management in the Baltic Sea (i.e., a common set of issues). The operational objectives tend to reflect the management requirements, while the indicators reflect the scientific requirements.

3.2.5 Developing Nature Conservation Objectives for the Irish Sea, United Kingdom

With its semi-enclosed geography and range of stakeholders and activities, the Irish Sea is considered to be one of the most recognisable and distinct regional seas around the UK (http://www.jncc.gov.uk/marine/irishsea_pilot/default.htm 2004). A pilot project, known as the Irish Sea Pilot, has been undertaken to test a proposed new UK marine nature conservation framework (http://www.jncc.gov.uk 2004). It falls under the Regional Seas Programme as part of the Oslo-Paris Commission (OSPAR).

The pilot aims to examine the potential for regional sea management over the whole Irish Sea, including involvement from the Government of Ireland, the Isle of Man, Scotland, Wales, and Northern Ireland. The aims of the Irish Sea pilot are to:

- Test ways of integrating nature conservation into key sectors in order to make an effective contribution to sustainable development on a regional basis;
- Test the framework proposed by the paper *An Implementation Framework for the Conservation, Protection and Management of Nationally Important Marine Wildlife in the UK*;
- Determine the potential of existing regulatory and other systems for delivering effective marine nature conservation, and identify any gaps; and
- Recommend measures to fill the gaps identified.

The pilot is charged with testing a proposed new marine nature conservation framework in the Irish Sea, prepared by the conservation agencies of the UK, English Nature, Scottish Natural Heritage, Countryside Council for Wales, and the Environment and Heritage Service. One of the outputs from the study is a set of objectives for nationally important conservation features to help guide the future actions of national, regional and local regulatory bodies and users (nature conservation objectives).

For the purpose of setting conservation objectives, the Regional Sea is considered as having three components: *physical and chemical properties*, *productivity* and *biodiversity*. The proposed aims for these components are to:

- Maintain the physical and chemical properties of the ecosystem;
- Maintain each component of the ecosystem so that it can make its expected contribution to the food web;
- Prevent further loss of marine biodiversity, and promote its recovery where practicable, so as to maintain the natural richness and resilience of the ecosystem.

For each of these aims a series of high-level conservation objectives has been developed (Table 6). Each high-level conservation objective has been further refined by the development of one or more "operational" conservation objectives. The operational conservation objectives are defined in one of the following ways:

- Compliance with standards aimed at protecting the marine environment;
- Protection or recovery from adverse impacts due to human activity; or

- Achievement of a particular target state or level.

Table 6 Aims, high-level objectives and conservation objectives developed for the Irish Sea Pilot Project

HIGH LEVEL OBJECTIVES	ECOSYSTEM COMPONENTS (ILLUSTRATIVE)	OPERATIONAL CONSERVATION OBJECTIVES
Aim 1: To maintain the physical and chemical properties of the ecosystem		
1. Protect seabed features so that they can support the processes, habitats and species characteristic of the marine landscapes.	Coastal morphology • coastal processes	1.1 Protect coastal processes from ecologically-significant change due to human activity, and reverse such change where practicable.
	Seabed habitats • substratum type • particle size composition • topography • substratum structure • siltation • physical processes • chemical processes	1.2 Protect seabed habitats from ecologically-significant change due to human activity, and reverse such change where practicable.
	Biogenic structures • saltmarshes • eelgrass beds • *Sabellaria* spp. reefs • *Modiolus* reefs	1.3 Protect biogenic structures from ecologically-significant change due to human activity, and reverse such change where practicable.
2. Protect water column features so that they can support the processes, habitats and species characteristic of the water bodies.	Water column features • Tides, waves, fetch, currents • Fronts • Stratification • Temporal changes • Freshwater inputs • Salinity • Suspended solids • Turbidity	2.1 Protect the water column features from ecologically-significant change due to human activity, and reverse such change where practicable.
3. Protect the water quality of the component water column features so they can support the processes, habitats and species characteristic of the water column and associated seabed habitats.	Water quality • Chemical conditions • Nutrients • Dissolved gases	3.1 Maintain or recover water quality to within defined standards that aim to prevent undesirable disturbance caused by eutrophication.
	Chemical pollutants • Contaminants • Organic compounds • Radioactive elements	3.2 Ensure that environmental standards are not exceeded.
	Oil • Chronic • Acute	3.3 Ensure that environmental standards are not exceeded. 3.4 Reduce the input of oil from accidents, as far as practicable.
	Noise and vibration	3.5 Maintain noise and vibration levels below precautionary standards aimed at protecting vulnerable marine species from disturbance.
	Marine litter	3.6 Reduce input of litter to the marine environment to below levels aimed at protecting vulnerable marine habitats and species.
4. Maintain biota quality.	Contaminants • Contaminant loads • Bioaccumulations • Health of animals	4.1 Ensure standards for contaminants in biota are not exceeded.
Aim 2: To maintain each component of the ecosystem so that it can make its expected contribution to the food web		
1. Maintain primary production	Trophic status	1.1 Ensure compliance with precautionary standards which

HIGH LEVEL OBJECTIVES	ECOSYSTEM COMPONENTS (ILLUSTRATIVE)	OPERATIONAL CONSERVATION OBJECTIVES
within bounds of natural variability.	• nutrient concentrations • water clarity • Chlorophyll *a* concentration	aim to avoid undesirable disturbance of trophic status.
2. Maintain trophic structure so that individual species and stages can sustain their characteristic roles in the food web.	Trophic complexity • number of trophic levels • biomass at each trophic level	2.1 Ensure harvest of all species at a specified trophic level is below precautionary limits.
	Habitat availability • pelagic habitats • benthic habitats • nursery areas • spawning areas • migration pathways	2.2 Protect the extent and function of habitats, areas and pathways from significant decline due to human activities.
	Predator-prey relationships • predator-induced mortality rates on prey populations • biomass of key dependent predators: ○ commercially exploited fish/shellfish ○ non-target fish species ○ benthic animals ○ birds ○ marine mammals	2.3 Reduce direct and indirect impacts upon prey populations to below levels at which their populations may be affected. 2.4 Reduce direct and indirect impacts upon key dependent predators to below levels at which their populations may be significantly affected.
3. Maintain mean generation times of populations within bounds of natural variability.	Longevity • survivorship curves • mortality rate	3.1 Protect populations from changes in longevity, which may have a significant impact upon the marine ecosystem, due to human activity.
	Life history strategy • changes in reproductive parameters (age of maturity, time of breeding) • lifetime reproductive success rates	3.2 Protect populations from changes in life history strategy which may have a significant impact upon the marine ecosystem, due to human activity.
	Reproductive potential • fecundity • spawning stock biomass	3.3 Enable the spawning stock biomass of commercially exploited fish/shellfish to recover to within safe biological limits. 3.4 Increase the spawning stock biomass of commercially exploited fish/shellfish stocks further, to within limits defined for an ecologically-sustainable fishery, where this is possible.
	Fishing mortality	3.5 Reduce fishing mortality of commercially-exploited fish/shellfish stocks to within safe biological limits. 3.6 Reduce fishing mortality of commercially-exploited fish/shellfish stocks further, to within limits defined for an ecologically-sustainable fishery, where this is possible.
Aim 3: To prevent further loss of marine biodiversity, and promote its recovery where practicable, so as to maintain the natural richness and resilience of the ecosystem		

HIGH LEVEL OBJECTIVES	ECOSYSTEM COMPONENTS (ILLUSTRATIVE)	OPERATIONAL CONSERVATION OBJECTIVES
1. Maintain habitats/ communities within bounds of natural variability.	Trophic level balance • Effective number of species within each trophic level • Abundance of keystone species	1.1 Protect the trophic level balance from significant changes due to human activity.
	Habitat complexity • overall number of habitats/communities	1.2 Prevent a significant decline in the habitat complexity of marine ecosystems due to human activity.
	Areas identified as being the best representative examples of the range of marine landscapes, water body features, habitats and species	1.3 Maintain the best representative examples in, or recover them to, as close to their natural state as practicable.
	Rare and sensitive habitats	1.4 Protect rare and sensitive habitats from decline due to human activity.
	Habitats which are threatened by decline or have declined	1.5 Protect threatened habitats from decline due to human activity. 1.6 Enable habitats which have declined to recover to a non-threatened state, where practicable.
	Non-native species	1.7 Prevent the introduction of non-native species that may adversely impact the marine environment. 1.8 Reduce impacts of existing non-native species to below levels that risk affecting the marine ecosystem, where practicable.
2. Maintain species within bounds of natural variability.	Overall diversity of species	2.1 Prevent significant changes in the overall species diversity of marine landscapes and water bodies due to human activity.
	Important areas for highly mobile and migratory species • spawning/breeding • nursery • calving • feeding • nesting • migration bottlenecks	2.2 Protect the important areas for aggregations of mobile species (e.g., spawning/breeding, nursery, calving, feeding or nesting areas, and migration bottlenecks).
	Species which are threatened by decline or have declined	2.3 Safeguard species which are threatened by decline due to human activity. 2.4 Promote the recovery of species which have declined, to a non-threatened state, where practicable.
3. Maintain populations within bounds of natural variability.	Structure among populations • metapopulation structure • distribution • habitat availability	3.1 Protect the structure among populations from significant change due to human activity.
	Structure within populations • population size • distribution • habitat availability • age structure	3.2 Protect the structure within populations from significant change due to human activity.
	Populations at risk	3.3 Protect populations defined to be at risk and recover them to non-at risk state, where practicable.
	Genetic diversity among populations	3.4 Protect the genetic diversity among populations from significant change due to human activity.
	Genetic diversity within populations	3.5 Protect the genetic diversity within populations from significant change due to human activity.

The purpose of defining conservation objectives at an operational level is to provide practical guidance for management. The format employed is designed so that the operational conservation objectives can be integrated with the ecological quality objectives being developed under OSPAR (see Section 3.2.6 on the North Sea). Progress towards achieving the operational conservation objectives will be assessed by defining and monitoring indicators and targets set for these objectives. These have not yet been defined.

The Irish Sea Pilot has used the Canadian "Dunsmuir" objectives as a starting point to identify ecosystem components (elements) and related operational objectives. It is an easily-understood linear framework for the development of ecosystem objectives only. It does not have a socio-economic or governance component to it.

The Irish Sea Pilot has also developed a clearly-defined terminology, which will be used consistently through the life of the project. This has established a common-ground for managers and scientists that are involved. The terminology differs from that currently used in ESSIM, although the constituents of the framework are the same as ESSIM.

Because of the complexity of ecosystems, some high-level objectives developed for the Irish Sea Pilot have similar components/elements. For instance, the objective *maintain habitats/communities within the bounds of natural variability* has a component related to trophic structure/status, as do the objectives *maintain primary production within bounds of natural variability* and *maintain trophic structure so that individual species and stages can sustain their characteristic roles in the food web*.

The objectives have not yet been linked with management actions and indicators for monitoring. However, the identification of ecosystem components together with the operational objectives provides a good platform for development of the other constituents.

3.2.6 North Sea Pilot Project, OSPAR

At the Intermediate Ministerial Meeting (IMM) on fisheries in Bergen in 1997, the Ministers of the North Sea countries agreed on *"further integration of fisheries and environmental protection, conservation and management measures, drawing upon the development and application of an ecosystem approach which, as far as the best available scientific understanding and information permit, is based on in particular:*

- *the identification of processes in, and influences on, the ecosystems which are critical for maintaining their characteristic structure and functioning, productivity and biological diversity;*
- *taking into account the interaction among the different components in the food-webs of the ecosystems (multi-species approach) and other important ecosystem interactions; and*
- *providing for a chemical, physical and biological environment in these ecosystems consistent with a high level of protection of those critical ecosystem processes"* (http://ioc.unesco.org 2004).

As a follow-up activity, a workshop on the ecosystem approach to the management and protection of the North Sea was held in Oslo in June 1998. This workshop identified monitoring as a key component of an ecosystem approach in relation to ecological objectives, assessments, and scientific advice to management (http://ioc.unesco.org 2004). The 5th North Sea Ministerial Conference met in Bergen, Norway, in 2002 and agreed to implement an ecosystem approach, which was defined as the integrated management of human activities based on knowledge about the ecosystem to achieve sustainable use and its protection (http://ioc.unesco.org 2004). This ecosystem approach included setting operational objectives, monitoring the status and trends in the ecosystem, and assessing the status of the ecosystem and the degree of human impacts. A priority science issue that was identified was the development of ecological objectives and indicators for monitoring changes in the ecosystem and for measuring the effects of management actions (http://ioc.unesco.org 2004). Ten ecosystem objectives were identified and defined in the Bergen Declaration, 2002 (see section 3.6.2).

In 2003, a pilot project to test and further develop the EcoQOs for the North Sea was undertaken by the International Council for the Exploration of the Sea (ICES) on behalf of OSPAR.

The framework used for developing EcoQOs was, by definition, an objectives-based framework. Originally ten EcoQO elements (or components) were identified for the North Sea Pilot Project, and agreed upon in the Bergen Declaration, 2002 (Table 7). After review, ICES recommended the following set of EcoQO elements for which objectives and indicators could be developed (http://ioc.unesco.org 2004):

- Spawning stock biomass of commercial fish species;
- Seal population trends in the North Sea;
- By-catch of harbour porpoises;
- Proportion of oiled common guillemots among those found dead or dying on beaches;
- Utilisation of seal breeding sites in the North Sea;
- Mercury concentrations in seabird eggs and feathers;
- Organochlorine concentrations in seabird eggs;
- Plastic particles in stomachs of seabirds;
- Local sand eel availability to blacklegged kittiwakes;
- Seabird population trends as an index of seabird community health;
- Changes in the proportion of large fish and hence the average weight and average maximum length of the fish community;
- Density of sensitive (e.g., fragile) species; and
- Density of opportunistic species.

Ecological quality element	Ecological quality objective
(a) Spawning stock biomass of commercial fish species	Above precautionary reference points for commercial fish species where these have been agreed by the competent authority for fisheries management
(c) Seal population trends in the North Sea	No decline in population size or pup production of > 10% over a period of up to 10 years
(e) By-catch of harbour porpoises	Annual by-catch levels should be reduced to levels below 1.7 % of the best population estimate
(f) Proportion of oiled Common Guillemots among those found dead or dying on beaches	The proportion of such birds should be 10% or less of the total found dead or dying, in all areas of the North Sea
(m) Changes kills in zoobenthos in relation to eutrophication	There should be no kill in benthic animal species as a result of oxygen deficiency and or toxic phytoplankton species
(n) Imposex in dog whelks (*Nucella lapillus*)	A low (< 2) level of imposex in female dog whelks, as measured by *Vas deferens* Sequences Index
(q) Phytoplankton chlorophyll *a*	Maximum and mean chlorophyll a concentrations during the growing season should remain below elevated levels, defined as concentrations > 50% above the spatial (offshore) and or historical background concentration
(r) Phytoplankton indicator species for eutrophication	Region area - specific phytoplankton eutrophication indicator species should remain below respective nuisance and or toxic elevated levels (and increased duration)
(t) Winter nutrient concentrations (dissolved inorganic nitrogen (DIN) and dissolved inorganic phosphate (DIP)	Winter DIN and or DIP should remain below elevated levels, defined as concentrations > 50% above salinity related and or region-specific natural background concentrations
(u) Oxygen	Oxygen concentration, decreased as an indirect effect of nutrient enrichment, should remain above region-specific oxygen deficiency levels, ranging form 4-6 mg oxygen per liter

Table 7 Ecological quality elements and objectives defined in the Bergen Declaration, 2002

Table 8 provides a summary of the key characteristics of the EcoQ elements, proposed objectives (where provided) and indicators for which information is available for the North Sea Pilot Project as reported by ICES (http://ioc.unesco.org 2004). Much of the information presented in Table 8 has been extracted from the ICES

Advisory Committee on Ecosystems Report for 2003 (http://ioc.unesco.org 2004), which does not always provide explicit EcoQOs or criteria.

Table 8 Summary of the key characteristics of the EcoQ elements, proposed objectives and indicators

ECOQ ELEMENT	ECOQO	CRITERIA	CURRENT INDICATORS
Spawning stock biomass (SSB) of commercial fish species	Stock is within safe biological limits	Estimate of SSB is above the precautionary reference point, or The estimate of fishing mortality is below the precautionary reference point or Both of the above were met	Historic performance of advice based on SSB Historic trajectory of the performance of advice based on fishing mortality Historic trajectory of the performance of advice based on SSB and fishing mortality Proportion of stocks within safe biological limits based on SSM, fishing mortality and both together
Seal population trends in the North Sea	No seal population in the North Sea should decline more than 10% over less than 10 years	Decline of seals should be less than 10% over a period less than 10 years	Spread of the Phocine Distemper Virus (PDV) epizootic in harbour seals Current estimates of the abundance of grey seals in North Sea waters Time series of annual changes in estimates of grey seal pup production at major UK breeding sites in the North Sea Time series of annual changes in harbour seal abundance from the Danish Straits and Skagerrak Time series of the recorded number of grey seals in the Schleswig-Holstein, Wadden Sea Counts of harbour seals in The Wash, UK Time series of counts of harbour seals from the German Wadden Sea.
By-catch of harbour porpoises	-	-	Estimates of harbour porpoise by-catch in the North Sea
Proportion of oiled common guillemots among those found dead or dying on beaches	Proportion of oiled common guillemots should be 10% or less than the total found dead or dying on beaches, in all areas of the North Sea	Oiled guillemots less than 10% of those found dead or dying	Differences in the oiling rates of common guillemots in the North Sea The decline in oil rates of common guillemots found dead along the North Sea coast in the Netherlands Change in the proportion of oiled common guillemots in the German Bight Five-year running mean of the percentage of oiled common guillemots found as complete corpses on Dutch North Sea coasts Oiling rate of common guillemot corpses found on beaches in winter for three parts of the German North Sea Coast
Utilisation of seal breeding sites in the North Sea	-	-	Breeding areas of harbour seals in the North Sea Breeding areas of grey seals in the North Sea

ECOQ ELEMENT	ECOQO	CRITERIA	CURRENT INDICATORS
Mercury concentrations in seabird eggs and feathers	Mercury input into the environment is reduced.	Mercury levels are below the reference level (from 100 years ago) in body feathers and eggs Common tern: 1 mg kg^{-1} Black-legged kittiwake 1.4 mg kg^{-1} Common guillemot: 1 mg kg^{-1} Northern gannet: 4.4 mg kg^{-1}	Spatial variation in mercury contamination of common tern eggs in 1996 and 1997 from breeding site of the Wadden Sea Mercury concentrations of feathers of Atlantic puffin from southwest Britain and Ireland from 1850 to 1990
Organochlorine concentrations in seabird eggs	Decrease organochlorines in seabird eggs to 0 ng g^{-1} egg	Targets are: <20 ng total PCBs g^{-1} egg fresh mass <1 ng total DDT and metabolites g^{-1} egg fresh mass <2 ng total HCB g^{-1} egg fresh mass <2 ng total HCH g^{-1} egg fresh mass	Temporal trends in the PCB contamination of Eurasian oystercatcher and common tern eggs from selected breeding sites of the Wadden Sea Spatial variation in organochlorine contamination of common tern eggs in 1996 and 1997 from breeding sites in the Wadden Sea
Plastic particles in stomachs of seabirds	Decrease the amount of plastics in the stomachs of fulmars to as little as possible		Number and mass of plastic particles of each defined type in the stomachs of samples of 50 to 100 beach-washed northern fulmars: - industrial plastic particles - user plastic particles - mass of "inert" chemical material
Local sand eel availability to blacklegged kittiwakes	-	-	
Seabird population trends as an index of seabird community health	Less than 20% decline in population size within a period greater than twenty years	Less than 20% decline in population size within a period greater than twenty years	Change in breeding numbers of seabirds of selected species at selected colonies
Changes in the proportion of large fish and hence the average weight and average maximum length of the fish community	Maintain the health of the fish community	-	Average weight of fish in the community Average maximum length of a fish in the community Long term trends in weight and maximum length of the fish community.
Density of sensitive (*e.g.*, fragile) species	-	-	-
Density of opportunistic species			

OSPAR has made use of the technical expertise of ICES to undertake an in-depth analysis of relatively few core EcoQOs. The identification of the original set of EcoQOs was through agreement obtained at a Ministerial Conference, and the recommendations made by ICES are based on technical expertise and knowledge. There seems to have been little stakeholder participation with users of the resource. This is one of the problems in dealing with an international sea such as the North Sea.

There is no clear framework for the development of the EcoQOs, nor is there a documented understanding of what their establishment means in terms of ecosystem management of the North Sea. It is assumed that the EcoQs are critical elements to maintain the health of the ecosystem. They do not include a socio-economic component.

The analysis conducted by ICES provides a detailed presentation of data availability and sampling methodologies. This is obviously an issue that needs to be taken into consideration in any indicator analysis. The capacity to measure the required indicators is critical to the success of any objectives-based indicators system.

ICES also described the current management approach for each EcoQO, and presented possible alternatives. It has to be kept in mind that measures might differ for each country, and thus the management approaches recommended are at the discretion of signatories to OSPAR.

3.2.7 Gulf of Maine Indicators, Gulf of Maine Council on the Marine Environment, Canada and United States

The Gulf of Maine Council on the Marine Environment is a U.S.-Canada partnership of government and non-government organizations working to maintain and enhance environmental quality in the Gulf of Maine. The aim is to allow for sustainable resource use by existing and future generations. One of the themes that has persisted through the Gulf of Maine Council's existence is the importance of viewing the Gulf of Maine as a single ecosystem, irrespective of political boundaries, and promoting cross-boundary collaboration to help manage the region's resources and address environmental concerns. This basic philosophy will help guide the Council toward one of its most ambitious long-term goals, which is to help identify and track a set of regional environmental indicators and produce a *State of the Gulf* report (www.gulfofmaine.org 2004).

With this in mind, an action plan for the five-year period 2001-2006 has been developed. The goals and objectives that have been developed for this include:

- **Goal 1: Protect and restore coastal and marine habitats** - Coastal and marine habitats throughout the Gulf of Maine are healthy and support the Gulf's diversity of plant and animal species:
    - Increase awareness and improve management of regionally significant habitats;
    - Increase habitat protection;
    - Increase habitat restoration;
    - Increase awareness and improve management of aquatic nuisance species; and
    - Enhance citizen stewardship.

- **Goal 2: Protect human health and ecosystem integrity** - Contaminants in the Gulf of Maine are at sufficiently low levels to ensure human health and ecosystem integrity:
    - Increase awareness and improve management of priority contaminants;
    - Identify reduction strategies for priority contaminants; and
    - Enhance citizen stewardship.

- **Goal 3: Encourage sustainable maritime activities** - The Council's vision for 2025 is that marine research and nature-based tourism provide unique and significant economic opportunities for the region. During the next five years, the Council will create strategies to achieve these new objectives:
    - Create and implement a marine research and monitoring strategy that responds to pressing management issues and supports regional economic development; and

- Develop and implement a nature-based tourism strategy that sustains the environment and the well-being of local people.

Efforts are currently underway to develop Gulf-wide environmental indicators. In December 2002, more than 100 representatives of government agencies, academia, and non-government organizations met in New Hampshire for the *Atlantic Northeast Coastal Monitoring Summit*, which explored the potential for integrated regional monitoring, and provided participants with a forum to discuss possible indicators. As a follow-up, the *Northeast Coastal Indicators Workshop* in January 2004 developed a draft set of regional indicators for six categories: fisheries, contaminants, eutrophication, aquatic habitat, coastal development and climate change. Regional efforts culminated in the *Gulf of Maine Summit* in the fall of 2004. The goal of the summit was *to assess the health of the Gulf of Maine ecosystem and resources from the bottom up, taking full advantage of and integrating all the initiatives (e.g., watershed monitoring, research, coordinated regional planning, habitat restoration, etc.) currently underway by many agencies, organizations and institutions in the Gulf*. The indicators are currently been further developed and tested.

The indicators for the Gulf of Maine were developed within an issues-based framework, presented as questions (Table 9).

Table 9 List of questions (issues) and indicators for the Gulf of Maine

QUESTION	INDICATORS
Fisheries	
1. What are the trends in and the status of exploited fisheries stocks?	• Proportion of stocks at or above targeted abundance or biomass • Age/Size structure of species from surveys and/or landings • Spatial distribution of fisheries species Spatial and Temporal Scales: Range of species or stocks; Annual to every 3-5 years
2. What are the effects of fishing on non-targeted species and their associated communities?	• Characteristics of bycatch and discards • Population levels for selected species • Species Diversity Spatial and Temporal Scales: Regional based on populations or stock, biogeographic boundaries; Seasonal
3. What are the effects of fishing and non-fishing activities on marine habitat and fisheries productivity?	• Area closed to fishing, both pelagic and/or benthic • Benthic diversity • Spatial distribution of bottom fishing Spatial and Temporal Scales: Region wide (based on biogeographic boundaries); 1 to 5 years depending on habitat to annually to continuous
4. What are the trends in the socioeconomic characteristics of fishing?	• Days at sea • Fleet composition • Commercial and recreational fishing economic value • Angler satisfaction • Overcapitalized fleets • Natural capital value • Market value for consumers
Contaminants	
1. How are contaminants in the region changing?	• Area of sediments that have contaminant levels above sediment quality guidelines • Level of contaminants in representative non-migratory organisms • Area of shellfish bed closure by state/province by year • Days of beach closure due to bacterial contamination by state by year Spatial and Temporal Scales: Specific water body scales; Event to annual to decadal
2. How is the input of contaminants changing over time and space?	• Annual chemical load to water bodies by state/province • Number of bacterial source investigations and sources eliminated by year by state/province Spatial and Temporal Scales: Water bodies region-wide; Annual to source specific

QUESTION	INDICATORS
3. Are management actions changing the extent and severity of human health effects?	• Incidences of human disease caused by consumption of fish and shellfish and recreational contact • Level of contaminants in representative fish/shellfish and at-risk humans • Annual number of beach and shellfish closures (re-openings) Spatial and Temporal Scales: Water bodies region-wide; Annual to source specific
4. How well are contaminant management actions protecting ecosystem integrity?	• Sediment quality measure by triad approach • Incidence of disease • Reproductive success • Quality of habitats as affected by contaminants Spatial and Temporal Scales: Water bodies region-wide; Annual to decadal scales
Eutrophication	
1. What are the extent, severity, and trends of eutrophication impacts?	• Dissolved oxygen • Chlorophyll *a* • Submerged aquatic vegetation • Water clarity Spatial and Temporal Scales: Estuary-wide; Seasonal to annual
2. What are the sources of nutrients, can they be controlled, how are they changing?	• Measured and modeled loads • Land use/cover (load proxy) • Population (load proxy) Spatial and Temporal Scales: Regional; Seasonal to annual to decadal
3. What is the state of management measures and how can they be optimized?	• Dissolved oxygen • Chlorophyll *a* • Submerged aquatic vegetation • Water clarity • Measured and modeled loads • Land use/cover (load proxy) • Population (load proxy)
Aquatic Habitat	
1. How is the extent, distribution, or use of coastal habitats (watersheds+ estuaries+ near and offshore) changing over time?	• Extent per habitat type over time o Large scale mapping, small scale ground surveys • Distribution per habitat type • Inventory of human use o Area, percent of public vs. private o Area, percent designated for permanent habitat protection
2. How is the ecological condition of coastal habitats changing over time?	• Community Structure o Measure of change of relative abundance of species within habitat • Trophic Structure • Species of Concern
3. What are the causes of coastal habitat change over time?	• Extent and percent habitat area altered by tidal restrictions • Boat registrations • Seagrass Nutrient Pollution Index • Indicators relating to other causes assumed covered by other groups Indicators are those of most important potential causes of habitat loss and degradation (physical and hydrologic alteration, nutrient loading, resource extraction, contaminants, climate change, sediment input)
Coastal Development	
1. What is the type, pattern, and rate of land use change?	• Percent change in land cover to more intensive uses • Demographic changes (population, *etc.*) • Types of land uses and change

QUESTION	INDICATORS
2. How are these changes impacting the integrity of coastal ecosystems?	• Integrity of coastal ecosystems for: o Threatened and endangered coastal species o Migratory species o Invasive species
3. How is the region responding to changes in coastal ecosystems?	• Type, location and pace of land conservation • Type, location and pace of habitat restoration • Land management (planning, regulatory, etc)
Climate Change	
1. What are the causes?	None identified
2. What are the impacts of climate changes to: weather, atmospheric & ocean circulation, ecosystems, and society?	• Precipitation trends • Storm frequency and intensity • Water temperature surface bottom • Relative sea-level rise Spatial and Temporal Scales: Regional; Annual to decadal
3. What are the impacts of climate change on biotic ecosystems?	• Warm vs. cold water finfish species diversity • Planktonic diversity • Wetlands extent, distribution and composition • Marine diseases indices (i.e., MSX, dermo, shell disease) Spatial and Temporal Scales: Regional; Annual

The indicators that are currently being prepared for the Gulf of Maine are issues-based rather than objectives-based. This is because they are aimed toward state of the environment reporting rather than towards integrated management.

3.2.8 IOC ICOM Indicators

The IOC, in conjunction with the DFO and NOAA, aims at promoting the development and use of ICOM indicators through the ICOM indicators initiative. *A Handbook for Measuring the Progress and Outcomes of Integrated Coastal and Ocean Management* (IOC 2005) has been developed by the IOC with the objective of developing a common set of indicators to be used to assess and report on the progress and results of ICOM programs throughout the world. The handbook promotes an outcome-oriented approach to the selection and application of indicators for ICOM, requiring objectives to be established for an ICOM project before indicators can be developed. The objectives and indicators in the handbook are currently being tested for ICOM initiatives in several countries.

The IOC handbook does not specify objectives and indicators in isolation of the ICOM process, but rather sees their development as part of the process. The ICOM process essentially has seven steps, including:

- Identify the organisation or body that has responsibility for the integrated management process;
- Define the management area;
- Engage affected interests;
- Undertake ecological and socio-economic assessments;
- Establish integrated management objectives and indicators;
- Develop and implement ICOM plans; and
- Monitoring, evaluation and reporting.

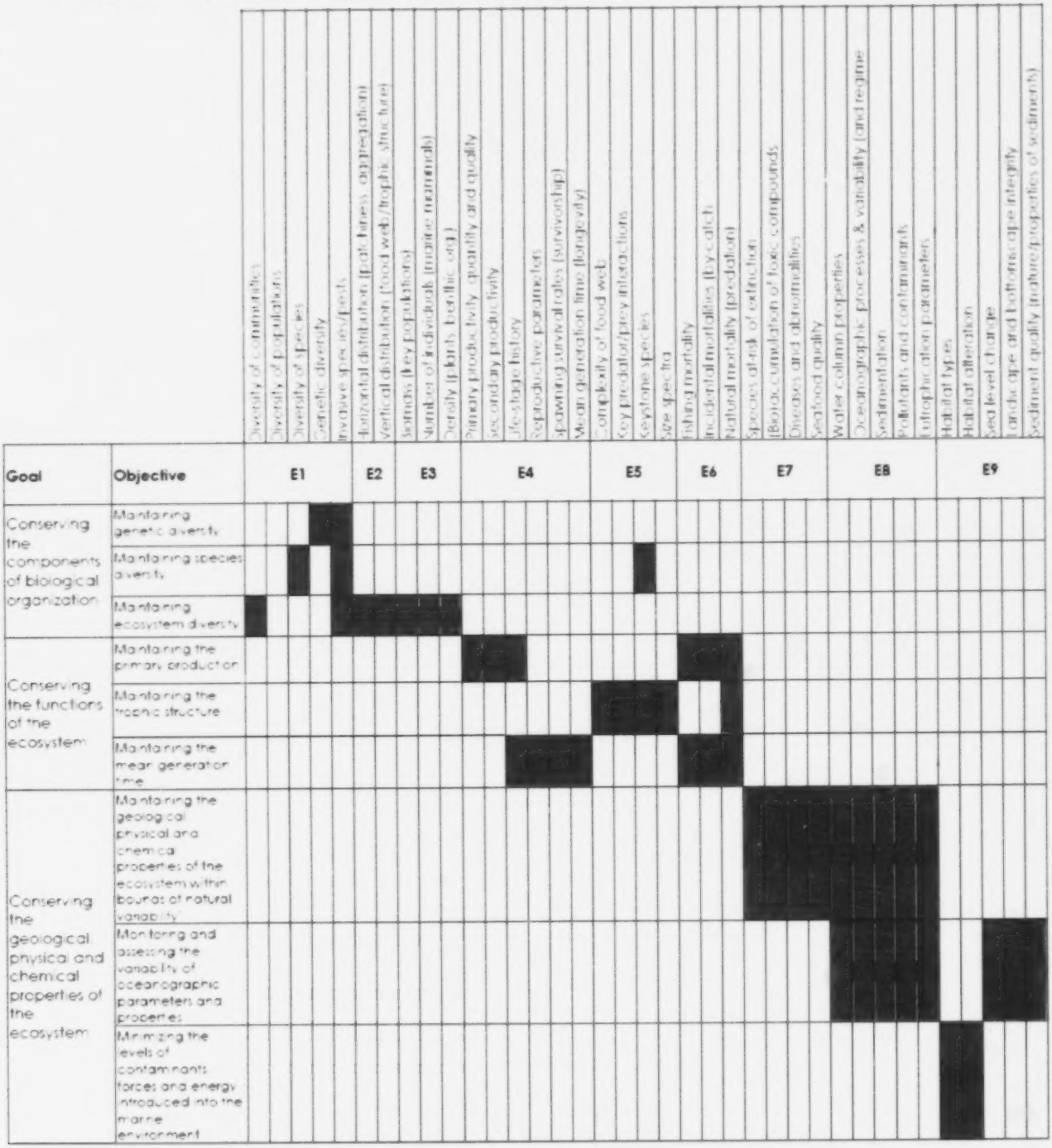
The IOC has developed a set of goals, objectives and indicators for ecological, socio-economic and governance aspects of ICOM, as shown in Tables 10, 11 and 12. A matrix system has been developed such that any indicator may provide information for one or more objectives within a set (ecological, socio-economic or governance). The goals, objectives and indicators presented in the handbook are not prescribed, but provide examples that may be utilised to varying degrees, depending on the situation.

The IOC ICOM indicators initiative is interesting in that it was begun after many of the other initiatives mentioned in this report. It was thus in a position to make use of previous knowledge. Much of the guidance in the handbook

is reminiscent of the ESSIM initiative and the Canadian influence can be seen in the choice of objectives and indicators and in the hierarchical structure.

This initiative uses a two-dimensional, rather than linear, method to integrate indicators and objectives and goals. One of the problems in developing objectives-based indicators is developing one or two indicators specific to an objective. In reality, indicators can represent more than one objective and, conversely, more than one objective may be measured by a single indicator.

Table 10 **Matrix of relevance of ICOM ecological indicators to goals and objectives**



Goal	Objective	E1	E2	E3	E4	E5	E6	E7	E8	E9
Conserving the components of biological organization	Maintaining genetic diversity									
	Maintaining species diversity									
	Maintaining ecosystem diversity									
Conserving the functions of the ecosystem	Maintaining the primary production									
	Maintaining the trophic structure									
	Maintaining the mean generation time									
Conserving the geological, physical and chemical properties of the ecosystem	Maintaining the geological, physical and chemical properties of the ecosystem within bounds of natural variability									
	Monitoring and assessing the variability of oceanographic parameters and properties									
	Minimizing the levels of contaminants, forces and energy introduced into the marine environment									

Table 11 **Matrix of relevance of ICOM socioeconomic indicators to goals and objectives**

Goal	Objectives	E1	E2	E3	E4	E5	E6	E7	E8
Maximizing sustainable wealth generation and the reduction of poverty	Exploiting sustainably living resources	■	■	■		■	■		
	Exploiting sustainably non-living resources	■	■	■					
	Ensuring sustainable non-consumptive uses	■	■	■			■		■
Minimizing environmental degradation from human activity	Managing sustainably exploitation and extraction	■		■		■			
	Minimizing pollution and litter	■			■		■		
	Minimizing introduced alien species	■			■				
	Minimizing habitat alteration and destruction			■	■	■			
Protecting human life public and private property and establishing or maintaining equitable population dynamics	Minimizing damage from coastal hazards							■	
	Ensuring public health				■		■		
	Ensuring public safety							■	
	Ensuring adequate population dynamics					■			■

Table 12 Matrix of relevance of ICOM governance indicators to goals and objectives

Goal	Objective	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	G12	G13	G14	G15
Ensuring the coordination and coherence of administrative actors and policies	Ensuring the coordination of administrative functions	■	■	■	■	■	■									■
	Enabling ICOM through a regulatory framework		■	■												
	Resolving conflicts among actors and stakeholders	■	■		■											
Ensuring the quality and effectiveness of management	Managing coastal uses in an integrated way					■	■									■
	Adapting management to changing conditions							■		■						
	Sustaining the ICOM process over time								■				■			
Improving knowledge awareness and support	Making optimal use of scientific information							■		■			■			
	Ensuring support to the ICOM process									■	■	■				
Mainstreaming ICOM into sustainable development	Supporting ICOM through appropriate technology												■	■		
	Supporting ICOM through economic instruments														■	
	Mainstreaming ICOM into sustainable development strategies															■

3.2.9 MPA Management Effectiveness Initiative, IUCN/WWF/NOAA

In keeping with their missions to support MPAs, their managers and constituents, the IUCN World Commission on Protected Areas (WCPA Marine) and the World Wildlife Fund for Nature (WWF) formed the MPA Management Effectiveness Initiative in 2000. The outcome has been a guidebook for assessing MPA management effectiveness, based on MPA objectives and indicators (Pomeroy *et al.* 2003). The guidebook does not prescribe objectives and indicators for MPAs, but rather suggests a methodology for developing these, based on the characteristics of individual MPAs under assessment.

The basis for an assessment of MPA management effectiveness is the setting of goals and objectives against which progress can be measured, and identifying indicators relevant to them. Pomeroy *et al.* (2003) have identified four main steps to this phase of the assessment:

1. Identify your MPA goals and objectives;
2. Match relevant indicators to your MPA goals and objectives (based on a selection provided in the guidebook);
3. Review and prioritise the identified indicators; and
4. Identify how selected indicators relate to one another.

The guidebook identifies three main areas or themes within which objectives and indicators should be developed: biophysical, socio-economic and governance. Within these areas some general goals and objectives have been identified, as well as a set of indicators. The indicators developed are not specific to each objective, but are integrated with the objectives using a matrix structure. The generic goals, objectives and indicators for the biophysical, socio-economic and governance themes are presented in Tables 13, 14 and 15 respectively.

Although the guidebook is aimed at evaluation of the management success of the MPA, it can equally be used to evaluate other defined ocean areas utilised for multiple purposes. It is interesting to note that, despite the fact that the aim of MPAs is to conserve ecosystems, for this initiative the objectives and indicators focus on *socio-economic and governance* aspects. This implies that the socio-economic and governance issues surrounding marine ecosystem management are as important as the ecosystems themselves. It is through the social, economic and governance structures that measures can be implemented that influence the ecosystem. This initiative also uses a matrix to integrate indicators and objectives and goals.

Table 13 Biophysical goals, objectives and indicators (Pomeroy *et al.* 2003)

	B1 Focal species abundance	B2 Focal species population structure	B3 Habitat distribution and complexity	B4 Composition and structure of the community	B5 Recruitment success within the community	B6 Food web integrity	B7 Type, level and return on fishing effort	B8 Water quality	B9 Area showing signs of recovery	B10 Area under no or reduced human impact
Goal 1 Marine resources sustained or protected										
1A Populations of target species for extractive or non-extractive use restored to or maintained at desired reference points	✓	✓				✓	✓			
1B Losses to biodiversity and ecosystem functioning and structure prevented			✓	✓	✓			✓		
1C Populations of target species for extractive or non-extractive use protected from harvest at sites and/or life history stages where they become vulnerable	✓	✓		✓		✓	✓		✓	✓
1D Overexploitation of living and/or non-living marine resources minimized, prevented or prohibited entirely	✓	✓		✓		✓	✓			✓
1E Catch yields improved or sustained in fishing area adjacent to the MPA	✓				✓		✓		✓	✓
1F Replenishment rate of fishery stocks increased or sustained within the MPA	✓	✓					✓		✓	
Goal 2 Biological diversity protected										
2A Resident ecosystems, communities, habitats, species and gene pools adequately represented and protected				✓	✓		✓		✓	✓
2B Ecosystem functions maintained						✓		✓	✓	
2C Rare, localized and endemic species protected	✓	✓		✓						
2D Areas protected that are essential for life history phases of species		✓	✓				✓	✓		
2E Unnatural threats and human impacts eliminated or minimized inside and/or outside the MPA				✓				✓		✓
2F Risk from unmanageable disturbances adequately spread across the MPA										✓
2G Alien and invasive species and genotypes removed or prevented from becoming established	✓			✓						
Goal 3 Individual species protected										
3A Focal species abundance increased or maintained	✓	✓	✓			✓	✓		✓	
3B Habitat and ecosystem functions required for focal species' survival restored or maintained			✓	✓		✓	✓	✓	✓	
3C Unnatural threats and human impacts eliminated or minimized inside and/or outside the MPA							✓	✓		✓
3D Alien and invasive species and genotypes removed from area or prevented from becoming established	✓	✓		✓						
Goal 4 Habitat protected										
4A Habitat quality and/or quantity restored or maintained			✓	✓	✓			✓	✓	
4B Ecological processes essential to habitat existence protected			✓	✓	✓			✓	✓	
4C Unnatural threats and human impacts eliminated or minimized inside and/or outside the MPA			✓	✓	✓			✓		✓
4D Alien and invasive species and genotypes removed or prevented from becoming established	✓		✓	✓				✓		
Goal 5 Degraded areas restored										
5A Populations of native species restored to desired reference points	✓					✓	✓		✓	
5B Ecosystem functions restored	✓	✓		✓				✓	✓	
5C Habitat quality and/or quantity restored or rehabilitated		✓	✓	✓				✓	✓	
5D Unnatural threats and human impacts eliminated or minimized inside and/or outside the MPA	✓			✓				✓	✓	✓

✓	B1 Focal species abundance
	B2 Focal species population structure
✓	B3 Habitat distribution and complexity
✓	B4 Composition and structure of the community
	B5 Recruitment success within the community
	B6 Food web integrity
	B7 Type, level and return on fishing effort
	B8 Water quality
✓	B9 Area showing signs of recovery
	B10 Area under no or reduced human impact

5E Alien and invasive species and genotypes removed or prevented from becoming established

Table 14 Socio-economic goals, objectives and indicators

	S1 Local marine resource use patterns	S2 Local values and beliefs about marine resources	S3 Level of understanding of human impacts on resources	S4 Perceptions of seafood availability	S5 Perceptions of local resource harvest	S6 Perceptions of non-market and non-use value	S7 Material style of life	S8 Quality of human health	S9 Household income distribution by source	S10 Household occupational structure	S11 Community infrastructure and business	S12 Number and nature of markets	S13 Stakeholder knowledge of natural history	S14 Distribution of formal knowledge to community	S15 Percentage of stakeholder group in leadership positions	S16 Changes in conditions of ancestral and historical sites, features and/or monuments
Goal 1 Food security enhanced or maintained																
1A Nutritional needs of coastal residents met or improved				✓												
1B Improved availability of locally caught seafood for public consumption				✓	✓											
Goal 2 Livelihood enhanced or maintained																
2A Economic status and relative wealth of coastal residents and/or resource users improved	✓						✓		✓		✓					
2B Household occupational and income structure stabilized or diversified through reduced marine resource dependency	✓								✓	✓		✓				
2C Local access to markets and capital improved											✓	✓				
2D Health of coastal residents and/or resource users improved				✓				✓			✓					
Goal 3 Non-monetary benefits to society enhanced or maintained																
3A Aesthetic value enhanced or maintained						✓										
3B Existence value enhanced or maintained						✓										
3C Wilderness value enhanced or maintained						✓										
3D Recreation opportunities enhanced or maintained						✓										
3E Cultural value enhanced or maintained						✓										
3F Ecological services values enhanced or maintained						✓										
Goal 4 Benefits from MPA equitably distributed																
4A Monetary benefits distributed equitably to and through coastal communities							✓			✓						
4B Non-monetary benefits distributed equitably to and through coastal communities				✓		✓		✓			✓				✓	
4C Equity within social structures and between social groups improved and fair															✓	
Goal 5 Compatibility between management and local culture maximized																
5A Adverse effects on traditional practices and relationships or social systems avoided or minimized	✓	✓														
5B Cultural features or historical sites and monuments linked to coastal resources protected		✓														✓
Goal 6 Environmental awareness and knowledge enhanced																
6A Respect for and/or understanding of local knowledge enhanced		✓											✓			
6B Public's understanding of environmental and social 'sustainability' improved		✓	✓											✓		
6C Level of scientific knowledge held by the public increased		✓												✓		
6D Scientific understanding expanded through research and monitoring		✓												✓		

Table 15 Governance goals, objectives and indicators

	G1 Level of resource conflict	G2 Existence of decision-making and management body	G3Existence and adoption of a management plan	G4 Local understanding of MPA rules and regulations	G5 Existence and adequacy of enabling legislation	G6 Availability and allocation of MPA administrative resources	G7 Existence and application of scientific research and input	G8 Existence and activity level of community organisations	G9 Degree of interaction between managers and stakeholders	G10 Proportion of stakeholders trained in sustainable use	G11 Level of training provided to stakeholders in participation	G12 Level of stakeholder participation and satisfaction in management	G13 Level of stakeholder involvement in surveillance and monitoring	G14 Clearly defined enforcement procedures	G15 Enforcement coverage	G16 Degree of information dissemination to encourage stakeholder compliance
Goal 1 Effective management structures and strategies maintained																
1A Management planning implemented and process effective			✓													
1B Rules for resource use and access clearly defined and socially acceptable				✓												
1C Decision-making and management bodies present, effective and accountable		✓														
1D Human and financial resources sufficient and used efficiently and effectively																
1E Local and/or informal governance system recognized and strategically incorporated into management planning																
1F Periodic monitoring, evaluation and effective adaptation of management plan ensured																
Goal 2 Effective legal structures and strategies for management maintained																
2A Existence of adequate legislation ensured					✓											
2B Compatibility between legal (formal) and local (informal) arrangements maximized or ensured																
2C National and/or local legislation effectively incorporates rights and obligations set out in international legal instruments					✓											
2D Compatibility between international, national, state and local rights and obligations maximized and ensured																
2E Enforceability of arrangements ensured					✓								✓	✓		
Goal 3 Effective stakeholder participation and representation ensured																
3A Representativeness, equity and efficacy of collaborative management systems ensured												✓				
3B Resource use capacity effectively built to participate in co-management											✓					

	G1 Level of resource conflict	G2 Existence of decision-making and management body	G3Existence and adoption of a management plan	G4 Local understanding of MPA rules and regulations	G5 Existence and adequacy of enabling legislation	G6 Availability and allocation of MPA administrative resources	G7 Existence and application of scientific research and input	G8 Existence and activity level of community organisations	G9 Degree of interaction between managers and stakeholders	G10 Proportion of stakeholders trained in sustainable use	G11 Level of training provided to stakeholders in participation	G12 Level of stakeholder participation and satisfaction in management	G13 Level of stakeholder involvement in surveillance and monitoring	G14 Clearly defined enforcement procedures	G15 Enforcement coverage	G16 Degree of information dissemination to encourage stakeholder compliance
3C Community organizing and participation strengthened and enhanced								✓								
Goal 4 Management plan compliance by resource users enhanced																
4A Surveillance and monitoring of coastal areas improved						✓							✓	✓	✓	
4B Willingness and acceptance of people increased to behave in ways that allow for sustainable management									✓				✓			✓
4C Local ability and capacity built to use resources sustainably										✓						
4D User participation in surveillance, monitoring and enforcement increased													✓			
4E Application of law and regulations adequately maintained or improved				✓	✓											
4F Access to and transparency and simplicity of management plan ensured and compliance fostered																
Goal 5 Resource use conflicts managed and reduced																
5A User conflicts managed and/or reduced: 1) within and between user groups and/or 2) between user groups and the local community or between the community and people outside	✓															

4.0 COMPARISON OF OUTCOMES

In 2004, when this review was first undertaken, many of the initiatives had just been initiated, or were in the preliminary stages of developing objectives and indicators. Although many have still not been finalised, and in many cases indicators have not been developed, there have been significant changes to them that indicate that they are maturing. This is also true of the ESSIM objectives, for which there was no complete set in 2004. Due to the preliminary nature of the objectives in 2004, it was difficult to provide a complete comparative analysis, although comparison between the initiatives was attempted (Walmsley 2004). The following provides a more complete comparison of the various initiatives, including ESSIM.

4.1 Development Approach

The development of objectives and indicators for each of the initiatives differed depending on the requirements of the project and expected outcomes. The diversity of approaches and even the outcomes of the initiatives reviewed indicate that there is no accepted methodology for the development of objectives and indicators. The aims and goals of each initiative determine the approach taken. Approaches can vary from participative to technical; based on a strict framework, to being fairly flexible; limited or inclusive, etc. Thus, there is no right or wrong way to approach the development of objectives and indicators for marine management.

The initiatives reviewed can be categorised as having used several different approaches, including:

- A **modelling approach**, such as that used by the North West Shelf Project of Australia. The advantage of modelling is that inter-relationships and complex behaviour of a system can be taken into account. The limitation of a model is that, although calibrated using empirical data, the model outputs can rarely be comprehensively tested.
- A **stakeholder-driven, issues-based approach**, such as was used by ESSIM, the ESD for Fisheries in Australia, and the Gulf of Maine initiative. In general, this approach takes into account the key environmental and management issues in an area and develops objectives and indicators to reflect the changes that are required to manage the system sustainably.
- A **science-based approach**, such as that used for the North Sea by OSPAR where the objectives and indicators were developed through ICES. The ecosystem objectives for ESSIM were also developed based on scientific understanding of the Eastern Scotian Shelf and the identification of those elements that were critical for management.
- **Development of a framework**, such as those developed by IOC and the MPA Management Effectiveness Initiative. These frameworks have not been developed specifically for an initiative, but provide a structure and examples from which organisations and countries can develop their own objectives and indicators.

Few of the reviewed initiatives use one approach exclusively, and most are a combination of a few of these approaches.

4.2 Comparison of issues

Although the approaches of the various reviewed initiatives differed from each other, many of the objectives or elements were common to more than one initiative. Table 16 provides a comparison of the issues addressed by the various initiatives, for which objectives or indicators were developed.

Table 16 Issues addressed by the initiatives reviewed

Issue/Element	ESSIM, Canada	ESD Australia	SE Regional Marine Plan, Australia	Baltic Sea EcoQOs, HELCOM	Irish Sea Pilot, UK	North Sea EcoQOs, OSPAR	Gulf of Maine, US & Canada	IOC ICOM	IUCN/WWF MPA Assessment
Ecosystem									
Communities integrity/ecosystem diversity	✓	✓*		✓*	✓		✓	✓	✓
Species diversity/integrity	✓	✓*			✓	✓	✓	✓	✓
Specific species at risk	✓			✓*	✓	✓		✓	✓
Population integrity (genetic diversity)	✓	✓*		✓*	✓	✓*	✓	✓	✓*
Primary production/eutrophication	✓				✓	✓	✓	✓	
Trophic structure	✓			✓	✓	✓		✓	
Habitat quality (physico-chemical)	✓		✓	✓	✓	✓	✓	✓	✓
Hazardous substances/pollutants	✓			✓	✓	✓	✓	✓	
Alien species				✓	✓		✓	✓	✓
Coastal systems							✓	✓	
Climate change							✓		
Socio-economic									
Access to/allocation of resources	✓		✓						✓
Community resilience	✓	✓					✓	✓	
Education, training and awareness	✓							✓	✓
Services and infrastructure	✓								
Human health, safety and security	✓			✓			✓	✓	✓
Cultural and heritage sites/cultural requirements									
Aboriginal people	✓	✓	✓						
Wealth generation	✓	✓	✓						✓
Equity	✓								✓
Non-monetary value enhanced	✓								✓
Sustainable exploitation/stewardship	✓		✓	✓			✓	✓	✓
Governance/Institutional									
Collaborative planning/co-ordination	✓		✓					✓	✓
Recognition of local/traditional governance systems	✓								✓
Policies and legislation	✓	✓							✓
Conflict resolution	✓								✓
User compliance	✓								✓
Regulator accountability	✓		✓						
Adaptive management	✓							✓	✓
Use of scientific information			✓					✓	
Efficient use of resources									✓
Establishment of MPAs			✓	✓					✓
Use of economic instruments								✓	

Note: * Fish stocks

Several observations can be made regarding the similarities and differences between the various initiatives (see Table 16):

- There is considerable overlap for ecosystem objectives. One of the reasons for this is that several of the initiatives focused on developing conservation objectives (e.g., Irish Sea Pilot and EcoQO development for the North Sea and Baltic Sea, Gulf of Maine Indicators). Another reason is the socio-economic and governance issues are not as well defined as the ecosystem issues. ESSIM, the IOC ICOM Indicators and the MAP Effectiviness Initiatives are the only initiatives that provide a comprehensive list of socio-economic and governance objectives.
- Most of the initiatives are oceans-based and do not reflect coastal concerns. Thus, objectives for coastal management are not as evident.
- Climate change is only overtly referred to by the Gulf of Maine initiative, while the IOC ICOM initiative is the only initiative to have an objective related to the use of economic instruments for ecosystem-based management.

4.3 Terminology

Most of the initiatives were hierarchical to a lesser or greater degree. However, the terminology used varied from initiative to initiative. Table 17 indicates the different terms used at the different levels for nine of the initiatives (excluding the Australian North-West Shelf Project). Any direct comparison of these initiatives needs to take these differences into account.

Table 17 Terminology used at different hierarchical levels (NW Shelf initiative excluded)

ESSIM	ESD for Fisheries	SE Regional Marine Plan	Baltic Sea EcoQOs	Irish Sea Pilot	North Sea EcoQOs	Gulf of Maine	IOC ICOM Indicators	MPA Effectiveness
Conceptual Objective	Core Objective		Strategic goal	Aim		Goal	Goal	Goal
Element	Reporting component			Component	Quality element			
Plan-level objective	Conceptual objective	Objective		High-level objective			Objective	Objective
Sub-objective		Outcome	Operational objective	Operational objective	Quality objective			
					Criterion			
							Indicator	
Indicator			Indicator		Indicator	Indicator	Measure	Indicator

The difference in terminology used may be reflective of the fact that the process of objective and indicator development in the marine environment is a relatively new science. During the development of the ESSIM objectives considerable time was spent debating and defining words and terms to ensure that there were no misconceptions with regard to each objective. The process itself is a marriage between science and management, and often the terms used by these disciplines vary sufficiently to cause misunderstanding.

4.4 Implementation

None of the initiatives reviewed has implemented the objectives and/or indicators. Some of the initiatives are currently going through the process of testing and further developing indicators (e.g., ESSIM Initiative, the IOC ICOM Indicators project, the Gulf of Maine indicators and the North Sea EcoQOs), but no reports are publicly available. Thus, there is no way to evaluate the success of these initiatives.

5.0 CONCLUSIONS

Objectives-based management is not a new concept in management circles. However, its application to marine systems provides challenges that may not be faced in, for instance, a business management context. In particular, marine ecosystems are highly complex and many of the functions and processes are not fully understood. This is further complicated by economic and social requirements of people who use the resources of the oceans. Developing objectives in an environment of inherent complexity is demanding and requires a high level of commitment on the part of resource managers.

One of the challenges faced by ESSIM at the beginning of the process to develop objectives and indicators was that there were no outstanding examples to follow. Over the past two years many of the objectives development processes around the world have advanced considerably, and a body of knowledge around the development of objectives and indicators is starting to emerge. This is assisted by the work of international organisations such as the IOC, IUCN and WWF who have supported the development of frameworks that include socio-economic and governance components, largely ignored prior to 2003. As the saying goes, "the proof of the pudding is in the eating". So far, none of the initiatives have implemented the objectives or the indicator reporting systems. Until such time as they do, the value of the objectives-based management approach to marine systems will remain unknown.

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